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I. ON THE GEOLOGICAL AGE OF THE DEPOSITS CONTAINING FLINT IMPLEMENTS, AT HOXNE, IN SUSSEX, AND THE RELATION THAT PALÆOLITHIC MAN BORE TO THE GLACIAL PERIOD.

By Thomas Belt, F.G.S.

CONCERNING the glacial period, geologists hold the most varied opinions, both with regard to its origin and to the mode of action of the ice. Thus at the very threshold of the geological record we tread on uncertain ground, and every guide points to a different path. The relation that palæolithic man bore to the great ice age might seem to be of easier solution; but even this question is unsettled, and a subject of controversy and doubt. Prof. Prestwich is believed by many to have proved that palæolithic man was post-glacial. Messrs. Croll and Geikie urge that there were two or more glacial periods in post-tertiary times, and that he flourished in a mild interglacial period. I, on the contrary, have been gradually forced to conclude that, in the British Isles, all the remains in caves and valley gravels referred to palæolithic man are preglacial, in the sense that they are of earlier date than the glaciation of the districts in which they are found.

I propose to state briefly some of the general arguments that have influenced my opinion, and then to deal with the special question of the age of the deposits at Hoxne, which the advocates of the post-glacial theory put forward as being undoubtedly in their favour.

Let us first take into consideration the age of the beds containing the remains of the mammoth, the woolly rhinoceros, and their companions, with which the palæolithic implements are so often found. Wherever, in Europe, the relation of these beds to the boulder clay can be clearly seen, they are of distinctly older age. Thus, in Russia, Sir Roderick Murchison has recorded the discovery of the bones of the mammoth and woolly rhinoceros, near Moscow, in reddish clay covered with erratic blocks, on the plains 13 miles distant from the river.* And if we follow the northern drift southwards from Moscow, as I have done, we find it gradually changes from clay with boulders to the clay without boulders that covers the southern plains. Around the sea of Azof, cliffs of this glacial clay, 100 feet high, can be followed continuously for miles, and its junction below with the older beds is sharply defined. It rests on a freshwater deposit containing shells of species of *Unio*, *Cyclas*, and *Paludina*, and at this horizon fragments of the tusks and bones of the mammoth are abundant, and are always undoubtedly older than the glacial clay. In a similar position the same remains have been found at Odessa and other places in the South of Russia.

Nor has the theory of the post-glacial age of the remains of the mammoth remained unchallenged by eminent geologists in England. Prof. Phillips† and Mr. Godwin Austen‡ long ago recorded their conviction that they belonged to an earlier period than the deposition of the boulder clay, and that when they occur in newer beds they have been derived from an older formation. The remains are so plentiful in the caves of the North of England that it is certain that the mammoth and rhinoceros were abundant. Yet nowhere in the glaciated parts of the country have the bones been found excepting where preserved from the action of the ice in caverns and fissures.

Thus, in tracing the limits of the northern ice on the eastern side of England, I have found that Durham and Northumberland were probably completely overflowed by it, excepting the upper parts of the Cheviots, as pointed out to me by Mr. Richard Howse. The ice streamed through from the west, around the southern and northern flanks of the Cheviots, down the valleys of the Tyne and the Tweed, and when approaching the eastern coast was deflected to the south by the great mass of ice that occupied and was flowing down the bed of the German Ocean. In Yorkshire the ice from the west was held back by the Pennine Chain, and did not coalesce with the German Ocean glacier, but stopped short, somewhere about an irregular line drawn from Keighley, north-eastward to near the mouth of the Tees. The German Ocean glacier only, as it were, grazed the high land bordering the coast until it reached the northern shores of Norfolk that stood out across its track. A large portion of Yorkshire was thus never glaciated by land ice, and in this area remains of the great extinct mammals have been found in and below the lowland gravels, as at Leeds and Market Weighton; but when we pass north-westward into the country where the striæ on the rock surfaces bear witness to the passage of land ice, no such remains are found, excepting in caverns and fissures of the old rocks.

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* Geology of Russia in Europe, p. 650.

† Geology of Yorkshire, 1829, vol. i., pp. 18 and 52.

‡ Brit. Assoc. Reports, 1863, p. 68.

The north-western side of England is much more glaciated than the north-eastern, and the mammalian remains have only been found where preserved in caves. The ice filling the Irish Sea reached to a height of 2000 feet on the western flank of the Pennine Chain. Probably reinforced from the westward it continued, in scarcely decreasing thickness, across the whole of Lancashire and Cheshire, and passed over into the drainage area of the Severn, down which valley it appears to have flowed for some distance. As soon as we get beyond its influence we again meet with mammalian remains in the lowland gravels, and in most of the southern valleys they are abundant.

If the mammoth and its associates roamed as far as the north of England, and even into Scotland, after the glacial period, their remains ought to be found in the valley gravels of the glaciated districts. They are, however, absent, and if we should be led to infer from this that they lived before the glaciation of the country, and accept the conclusion of Prof. Phillips and Mr. Godwin Austen that the mammoth and the woolly rhinoceros lived before and not after the glacial period in Great Britain, we can scarcely refrain from going farther than these geologists and concluding that the makers of the palæolithic implements were also preglacial. For no geological inference seems based upon sounder evidence than that palæolithic man was contemporaneous with the mammoth and its associates. The implements of the one and the bones of the others are found together in the same stratum of the cave earth, and in all the numerous caverns that have been searched in England and Wales, there is no record of palæolithic implements being found at a higher horizon; when flint weapons do so occur they are invariably of the neolithic type. If geological evidence of contemporaneity is of any value, the occupation of the caves by palæolithic man ceased at the same time as the great mammals disappeared.

Let us look at the question from another point of view. In the south of England the remains of the mammoth are abundant in the valley gravels. They are found mixed through them or more commonly at their base. Palæolithic implements are found in the same position, though usually in gravel higher up on the slopes of the valleys. When found in the gravel, the bones are broken and worn, and the flint implements have their angles rounded more or less as if by rolling. When, as has happened in a few cases, the bones and implements have been found below the gravels, they have been uninjured and unworn. Mr. Godwin Austen noticed the occurrence of bones of the mammoth in an old forest bed beneath the valley gravels, at Peasemarsh, in Surrey, uninjured and lying together, whilst in the overlying gravel, the teeth of the mammoth were found singly and rolled.* And Colonel Lane Fox has recorded the discovery of flint implements at Acton in seams of white sand, 9 feet from the surface, beneath deposits of gravel and brick-earth.† Their edges were as sharp as if just flaked off a core of flint, whilst those found in the gravel, on the contrary, have their edges worn and rounded just like those of the subangular pebbles of which the gravel is principally composed.

The position and the state of preservation of the bones and implements are such as might be expected if they had been deposited on an old land surface before the outspread of the gravels, when the configuration of the country was much the same as now; and I have suggested that the occurrence of the implements, generally higher up the slopes of the valleys than the mammalian remains, is due to palæolithic man having frequented more elevated and drier localities than the great mammals. I have urged that the outspread of the gravels was due, as formerly supposed by Sedgewick, De la Beche, and Murchison, to the action of a great flood or debacle. I have advanced the theory that that debacle was caused by the breaking away of a barrier of ice that blocked up the English Channel, and with it all the drainage of Northern Europe, causing an immense lake of fresh or brackish water that was thus suddenly and tumultuously discharged.‡

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* Quart. Journ. Geol. Soc., vol. vii., p. 288.

† *Ibid.*, vol. xxviii., p. 456.

‡ Quarterly Journal of Science, April, 1875. Quart. Journ. Geol. Soc., vol. xxxii., p. 84.

This great flood occurred, according to my theory, before the culmination of the glacial period, and was primarily due to ice filling the bed of the North Atlantic as far south on the European side as lat. 49°. If the gravels in and below which the rude flint implements and the remains of the extinct mammals are found, were thus spread out, it follows that they were preglacial in the sense that they lived before the principal glaciation of the country.

We have seen that in the north such an excellent geologist as the late Prof. Phillips had arrived at this conclusion with regard to the age of the mammoth, the woolly rhinoceros, and the hippopotamus, and in the south, Mr. Godwin Austen, from a study of the same remains in the valley gravels. Direct evidence of great value has been added by Mr. Tiddiman in his reports on the exploration of the Victoria Cave, at Settle. He has shown that the cave deposits lie beneath glacial clay and amongst the other remains a human fibula has been found.* In the Cefn Cave, in Denbighshire, Mr. Mackintosh has also determined that the mammalian remains lie in and below a glacial clay.†

All the lines of enquiry thus far pursued in this paper point to the pre-glacial age of the remains in question, and some of the facts are directly opposed to the post-glacial theory. How then is it that the great majority of geologists write as if it had been clearly proved that palæolithic man was of post-glacial age? Principally because it is believed that Prof. Prestwich has proved that at Hoxne, in Suffolk, the implements and bones are found in deposits distinctly overlying boulder clay. This is spoken of as if it were a truism in most general treatises on geology;‡ and both in Europe and America the presumption is appealed to as being conclusive with regard to the age of the remains. The general opinion held is concisely given in the statement by Mr. John Evans in his Presidential Address to the Geological Society last year, that at Hoxne "the implement-bearing beds repose in a trough cut out in the upper glacial boulder clay, which itself rests on middle glacial sands and gravels."||

This opinion of the age of the Hoxne deposits is founded on the elaborate memoir by Prof. Prestwich, published in the "Philosophical Transactions of the Royal Society," for

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* Nature, vol. ix., p. 14. Brit. Assoc. Reports for 1873, 1874, 1875.

† Quart. Journ. Geol. Soc., vol. xxxii., p. 91.

‡ SIR CHARLES LYELL, Antiquity of Man, p. 166. J. GEIKIE, Great Ice Age, p. 474. J. CROLL, Climate and Time, p. 241. W. BOYD DAWKINS, Cave Hunting, p. 410. JUKES's Students' Manual of Geology, p. 736.

|| Quart. Journ. Geol. Soc., vol. xxxi., p. 74.

1860. In this treatise the author gives a diagram showing the deposits in question lying in a trough cut out in the boulder clay. Though this section is confessedly only theoretical, it was accepted by Sir Charles Lyell and others as an actual one, and afterwards the author himself wrote as if he had proved his theory to be true,* which he may well be excused for having done, when it had been accepted by so many eminent geologists.

The writings of Prof. Prestwich are admirable in this, as in other respects, that although he indulges in wide-reaching theories he invariably gives the evidence on which they are founded. Thus, in the memoir in question, in addition to the theoretical diagram he gives another, showing the actual facts observed, and also careful details of the various sections observed by him. It is therefore possible to check his theory by his facts, and in the present paper I shall do so, and also give the results of my own examination of the Hoxne district.

Mr. John Frere, so long ago as the first year of the present century, communicated to the Society of Antiquaries an "Account of Flint Weapons discovered at Hoxne, in Suffolk."† He stated that they were found in great numbers in a bed of gravel which was overlaid by 1 foot of sand with shells, and containing the jaw-bone and teeth of an enormous animal; the sand being again covered by 7½ feet of brick clay. Mr. Frere noticed that the strata lay horizontally, and had been denuded to form the present valley, and therefore concluded that they belonged to a period when the configuration of the surface was different from what it is now, and he considered that their antiquity was possibly "even beyond that of the present world." The manner in which the flint implements lay, and their great abundance, led Mr. Frere to conclude that a manufactory of them had been carried on at the place where he found them.

The discovery does not appear to have excited any attention at the time, and for more than half a century remained unnoticed. In 1859, when the discovery of flint implements in the Valley of the Somme, in France, in association with the remains of the mammoth and other extinct mammals, had at last aroused the attention of geologists, Mr. Frere's memoir was brought by Mr. John Evans before the notice of Mr. Prestwich, who had just returned from Amiens. He soon after visited Hoxne, and carefully examined into the facts of the case. He found that the bed of brick clay was still being worked, and that flint implements were occasionally, though rarely, turned up; and on a subsequent visit with Mr. Evans they succeeded in disinterring one themselves.

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* Philosophical Transactions, 1864, p. 253.

† Archæologia, 1800, vol. xiii., p. 206.

The valleys of the Waveney and its tributaries are bounded by low hills of gravel and boulder clay. The bed rock is not seen in any of the sections exposed, but it is supposed to be chalk. The gravels and sands (the middle glacial sands and gravels of Mr. Searles Wood, jun.) are exposed in many gravel-pits on both sides of the Waveney. They are sometimes capped by the upper boulder clay; at others, by a more sandy bed with stones (the "trail" of Mr. Fisher), which in some of the sections graduates into the upper boulder clay, of which I believe it to be the modified representative. One of the deepest sections on the north bank of the Waveney is near the road from Diss to Harleston, at Billingford, where the series of beds shown in Fig. 1 are exposed.

Fig 1

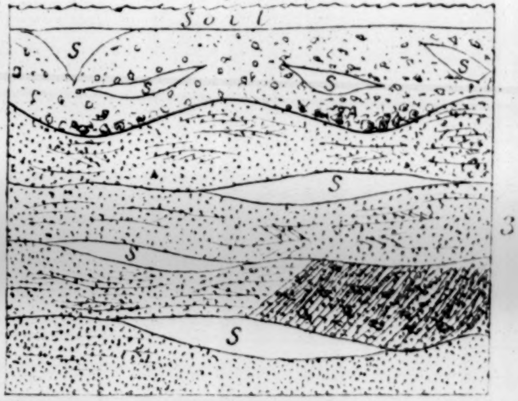

Fig. 1.—Scale 12 feet to 1 inch. 1. Sandy clay or "trail," with patches of sand (s) and scattered flints, mostly in nests, at the irregular base of the deposit. 3. Sands and gravel, false bedded with lenticular beds of sand (s), and in the lowest seams rounded pebbles of chalk.

Mr. Fisher some time ago called attention to the great importance of the upper bed, or "trail," in the study of the glacial beds,* but it has not yet received the notice it deserves. It is the most persistent of all the beds in the South-eastern counties, and can be traced, in almost every section, from Norfolk into Surrey. It is everywhere seen in the Thames valley lying on the top of the lowland gravels, and is shown in great perfection in the long section now (March, 1876) exposed between Acton and Hanwell, on the

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* Quart. Journ. Geol. Soc., vol. xxii., p. 553.

Great Western Railway. It generally, if not always, rests upon an irregular surface of the beds below it, and contains stones derived from some other source.

On the south side of the Waveney, at Syleham, there are good sections on both sides of the turnpike, and these exhibit similar false-bedded sands and gravels, which are, however, covered by the upper boulder clay instead of by "trail." Fig. 2 shows a section exposed on the south side of the turnpike. A little further west, on the north side of the turnpike, is another gravel-pit, showing a similar succession, but with the beds of sand and gravel strongly false-bedded. In all these sections small pebbles of chalk are very abundant in the lowest beds. The most remarkable feature in the Upper Boulder Clay is the numerous angular patches of material quite different from the matrix of brown clay. The angular patches of red sand are very peculiar, and difficult to explain.

Fig. 2.

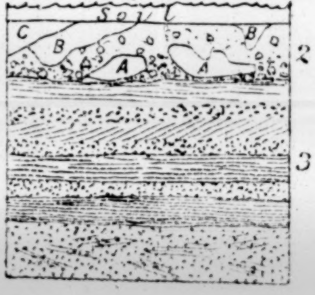


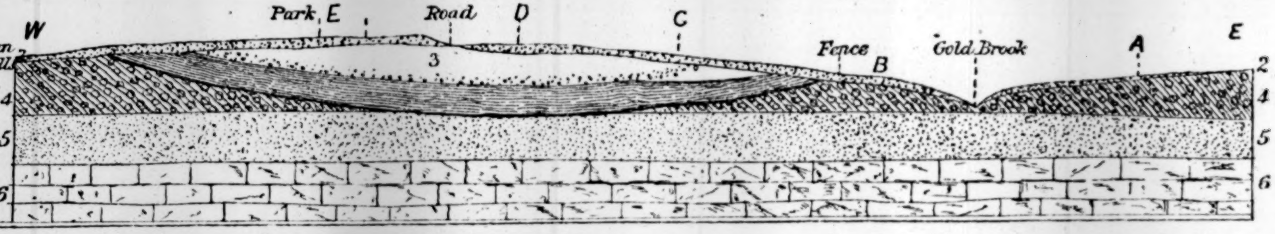
Fig. 2.—Brown boulder clay, with many whole flints, and with angular patches of red sand (B), marly clay with small stones (A), and red boulder clay (C). 3. Sands and subangular flint, gravel with rounded pebble of quartz, and (in the lowest seams) of chalk.

In a large gravel-pit a little north of Oakley Church there is a long section exposed, and in it the Upper Boulder Clay, similar to that shown in Fig. 2, at one end of the pit, gradually changes into a sandy loam with stones and angular patches of sand, not to be distinguished from the deposit named "trail" in Fig. 1.

At Hoxne itself, on the east side of Gold Brook, there is a gravel pit showing seams of gravel and sand exactly similar to that at Syleham, but surmounted by sandy "trail" instead of by boulder clay. The gravel is not to be distinguished from the other, being composed like it of sub-angular flint pebbles with rounded ones of quartz and quartzite, and with many small pebbles of chalk in the lowest seams. Notwithstanding this great similarity, Mr. Prestwich considers the beds at Hoxne to have been formed by river action in post-glacial times, whilst those at Syleham, being capped by boulder clay, he of necessity classifies as middle glacial. Yet I could find no difference whatever in their appearance or composition. In both, the pebbles are mostly small and subangular, with some rounded ones of quartz and quartzite. Both contain many small pebbles of chalk in their lowest seams, and both are false-bedded. That one is covered with boulder clay and the other by sandy "trail" does not suffice to prove them of different age, for at the Oakley gravel-pit we can trace the same gravels from one end, where the boulder clay overlies them, to the other, where the "trail" does so. The middle sands and gravels are generally supposed by geologists to be marine, and it is incredible that deposits due to such different agencies as that of the waves of the ocean beating on a beach, and that of a flooded river, should be absolutely identical in appearance and composition. But nowhere is either the ocean or any river known to be forming deposits of subangular pebbles, excepting where they are cutting into pre-existing beds of the middle glacial series. Both in sea and in river beaches the pebbles are smoothly rounded, and not, as in the gravels under consideration, broken and subangular. Even when we find in the latter rounded pebbles of tertiary age, there is often a piece chipped out of them, as if they had been dashed violently together. I have had a large number of the pebbles from the gravel at Ealing counted, and find that over 80 per cent are broken or subangular. I ask where, in the whole world, is such a deposit being formed by existing agencies? Surely if ordinary floods would produce them they have had plenty of opportunities of doing so during the past pluvial year, yet where, on the banks of any of our rivers, have the great floods left deposits even approaching in character to those that geologists confidently ascribe to river action? That they were caused by a great flood I fully believe, though not to that of any river, but to one that swept over the whole country, driving a huge mass of gravel and sand, and leaving them mantling both hills and valleys, holding or covering up the remains of palæolithic man and the great mammals that had lived before the waters were pent up by the Atlantic glacier.

A little above Hoxne, on the left side of the stream called the Gold Brook, is the Hoxne clay-pit. The clay is excavated along the slope of the shallow valley through which the brook runs. The road to Eye skirts the hill side, having to the west the park of Sir Edward Kerrison, and to the east, between it and the stream, a narrow strip of land from which

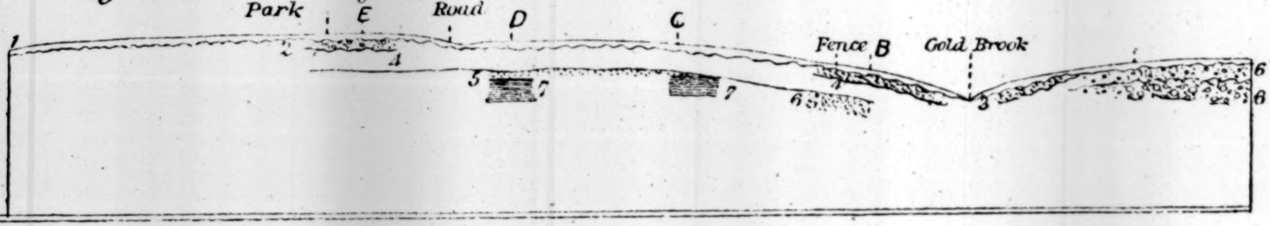
Fig 3. Theoretical Section according to Profesr Prestwich



EXPLANATION

2. Surface gravels.
3. Brick earth & gravel with flint implements mammalian remains & land & freshwater shells
3'. Peaty bed with wood & land & freshwater shells.
4. Boulder Clay.
5. Sands & gravels.
6. Chalk probably.

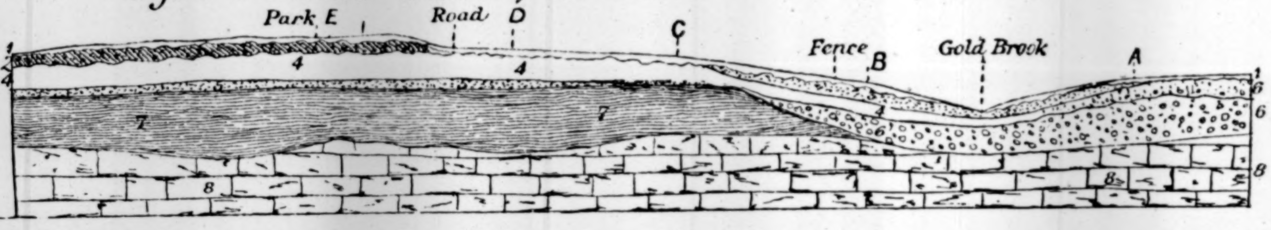
Fig. 4. Section shewing the actual Facts observed.



EXPLANATION.

1. Surface gravels "Trail"
2 Clay resembling "upper boulder clay"
3 False bedded sands & gravel. Flint
4. Brick earth Flint implements scarce Land & Freshwater shells. in lower part.
5 Gravel. many flint implements found by Mr Frere.
6 Lower boulder clay & "Till"
7 Peaty bed.

Fig. 5. Theoretical Section by the Author



EXPLANATION.

1. Trail
2. Upper Boulder Clay.
3. Middle Glacial sands & gravel
4. Brick earth "Glacial"
5. Chalk gravel.
6'. Lower boulder clay.
6. "Till".
7. Preglacial peaty clay.
8. Chalk, probably.

the clay has been dug. The old workers had commenced near the village of Hoxne, and as they gradually exhausted the clay up to the road they moved further southward, and the point at which it is now excavated is probably at least a quarter of a mile distant from that where Mr. Frere made his discoveries in 1800. The pit has now been worked up to some farm buildings that interfere with its progress southward, and to get clay they have now crossed the road into the park, and thus made a most important addition to the section laid open.

I have in the accompanying plate given three sections of the ground. The first shows the theoretical relation of the beds according to Prof. Prestwich. The second exhibits the facts actually observed by Prof. Prestwich and myself; and the third is a theoretical section, showing the relation that the beds hold to each other according to my own views. We shall in the first place confine our attention to the second section, Fig. 4, showing the facts actually observed.

Fig. 6

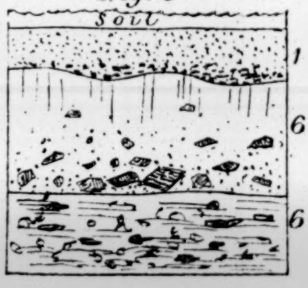


Fig. 6.—1. "Trail," 3 feet. 6′ and 6. Boulder clay, chalky in upper part. A slight line of division between it and the lower part, which is principally composed of crushed Kimmeridge clay with pieces of chalk.

On the east side of Gold Brook a cutting has been made into the bank, and a thick bed of boulder clay is exposed. At the point A in general section the beds are shown as in Fig. 6. Near the line of division the upper and more chalky clay contains many large flints and transported boulders. Some of these are smoothed, and strongly scratched and grooved. Two scratched blocks of septaria that I saw measured 1½ feet across. This boulder clay, both in its upper and lower division, is very distinct in appearance and composition from that lying above the gravels as seen in other sections. Lower down towards the brook a seam of false-bedded sandy gravel comes in between the boulder clay and the "trail," and represents, I think, the gravels of Figs. 1 and 2.

Crossing the brook and ascending the opposite slope, we have, at the points C and D of general section, typical sections of the clay-pit, as shown in Fig. 7. The clay, 4 in section, is called "red brick earth" by the workmen, because it burns to a red colour; whilst the lower dark-coloured clay, 7 in section, is called "white brick earth," because it burns to a white colour. The bottom of the latter bed has not been reached, although Prof. Prestwich had a boring put down into it to a depth of 17 feet. It is full of vegetable matter, and I found numerous pieces of wood in it. The men pointed out to me the gravel seams, 5 in section, as the horizon at which flint implements had been found; but shortly before Prof. Prestwich visited the pit, two specimens had been taken from the lower part of the clay, 4 in section. There can be little doubt, however, that they were found by Mr. Frere in the gravel below the "red brick earth," as he says that—"They lay in great numbers at the depth of about 12 feet in a stratified soil, which was dug into for the purpose of raising clay for bricks. Under a foot and a half of vegetable earth was clay seven and a half feet thick, and beneath this one foot of sand with shells, and under this two feet of gravel, in which the shaped flints were found generally at the rate of five or six in a square yard. The manner in which the flint implements lay would lead to the persuasion that it was a place of their manufacture, and not of their accidental deposit. Their numbers were so great that the man who carried on the brick-work told me that, before he was aware of their being objects of curiosity, he had emptied baskets full of them into the ruts of the adjoining road."

Fig 7

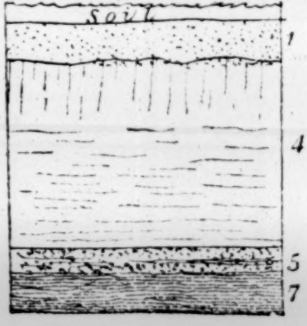


Fig. 7.—1. Sandy "trail" with flint pebbles. 4. Yellowish brown clay, unstratified at top and graduating downwards into obscurely stratified chalky clay: 10 feet. 5. Two thin bands of small chalky gravel, separated by 8 inches of loam. 7. Dark calcareous clay, with fragments of wood and other vegetation.

As I have already mentioned, the place at which the clay is now excavated is some distance from that where Mr. Frere found the implements, and they are now very seldom met with,—so seldom that none of the men working at the clay-pit when I was there had ever seen one.

To the west of the road, in the pit that has been opened in Sir Edward Kerrison's park, a section of the beds has been exposed at the point marked E in general section, as shown in Fig. 8. The most remarkable feature in the section is the occurrence of the upper clay, 2 in section, containing angular patches of red sand, like that seen in the "upper boulder clay" of other parts of the district. I cannot help thinking that if this section had been open when Prof. Prestwich examined the deposits he would have been led to modify his opinion respecting the relation of the deposits to the glacial period. I myself believe this clay to be the upper boulder clay, and the sand with pebbles below it to be the "middle glacial sands and gravels."

Fig. 8.

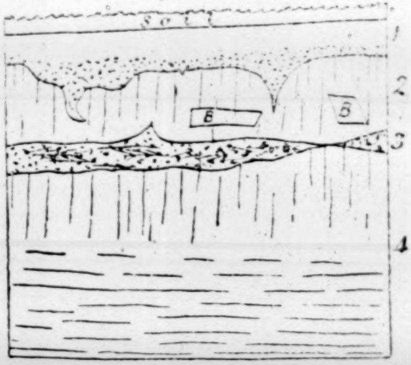


Fig. 8.—1. Sandy "trail" with flints graduating downwards into sand, filling pipes in clay below. 2. Unstratified yellow clay, containing isolated angular patches of reddish sand. 3. Whitish sand with a few scattered pebbles, sometimes changing into reddish sand, like that of the patches in the clay above. 4. Yellowish brown clay ("red brick earth"), unstratified at top and graduating downwards into laminated calcareous clay.

To trace the "red brick earth," 4 in section, down towards the lower boulder clay, I set some men to work, and had a shaft sunk—at the point marked B in general section—to a depth of 17 feet from the top of the surface soil, and obtained the section shown in Fig. 9. The most noticeable feature in this section is the thickening out of the false-bedded sands and gravels, their resemblance to the middle glacial series, and the absence of the "white brick earth," 7 in section. In a pit a little east of this, Prof. Prestwich and Mr. John Evans found a flint implement in the gravel bed, 3 in section.

I have now given all the facts at present known respecting the relation of these beds to the glacial period, and I proceed to the consideration of Prof. Prestwich's theoretical views, as shown in the general section, Fig. 3. In the first place, Prof. Prestwich identifies the boulder clay seen in the pit on the east side of the brook as the upper boulder clay. As I have already mentioned it in no respect resembles the clay seen in other sections above the false-bedded sands and gravel, and the existence of the middle glacial beds below this particular deposit is entirely theoretical. Prof. Prestwich makes these sands and gravel to pass under the brick clays; and I feel confident it will astonish many of those who appeal to this section, as proof of the post-glacial age of palæolithic man, to learn that they have never been seen in this position, and that their presence is an assumption only. The "red brick earth" ought, according to Prof. Prestwich's views, to thin out eastward, and the dark clays or "red brick earth" to crop up to the surface from underneath it. Instead of this, as shown in Fig. 8, at the point B in general section, the "red brick earth" follows down the slope of the hill, and is not underlaid at all at that point by the dark clays. I do not, however, attach much importance to this, as the "red brick earth" might mantle the hill, overlapping the edge of the dark clays, and yet Prof. Prestwich's general idea of the relation of the latter to the glacial beds be correct. What I do wish to point out is, that that relation is not proved by any of the facts known, and that an entirely different interpretation is not only possible,

Fig 9

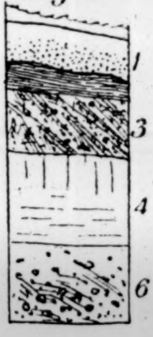


Fig. 9.—1. Sandy "trail" with flints: 3 feet. 3. False-bedded sand and subangular gravel: 4 feet 6 inches. 4. "Red brick earth," yellow and unstratified at top, graduating downwards into grey, laminated, calcareous clay; shells of *Bithinia tentaculata* and *Limnea palustris* abundant at its base, where there is about 6 inches of sandy clay: 4 feet 6 inches. 6′. Clay similar at top to the lower part of the "red brick earth," but with more chalk grains, gradually getting more chalky downwards, and with stones like the upper portion of the lower boulder clay at point A in general section.

but more probable. That other interpretation I have indicated in the general section, Fig. 5, in which all the facts observed are incorporated. I consider that the dark clay with vegetable remains and bones of the large extinct mammals is pre-glacial, in the sense that it is older than any of the glacial beds of the district. The gravel below the "red brick earth" in which Mr. Frere found the flint implements is probably of the same age, or of that of the overlying gravel, 5 in Figs. 4 and 5. That the implements, and also fragments of bones and wood, should be occasionally found in the overlying deposits, is what might be expected, as they were in great measure formed by the denudation of the older ones. The "red brick earth," 4 in section, is, I believe, a true glacial clay, belonging to the latter part of the first European lake. It is a noticeable fact that all over Northern Europe the glacial clays burn to a red colour,—a point not without significance with regard to the red beds of Permian or Triassic age. The false-bedded sands and gravels (3 in Figs. 4 and 5) belong, I think, to the middle glacial series, and the clay (2 in Figs. 4 and 5) is, I think, the upper boulder clay. These views are only theoretical, but I claim that they are based upon as sound a foundation, and are as much in accordance with the facts of the case, as those generally received.

Another interpretation is tenable, namely, that the lower boulder clay underlies the brick clays, and that the upper boulder clay overlies them, whilst they themselves belong to a warm interglacial period, as held by Messrs. Croll and Geikie. I do not agree with this opinion, as I can nowhere find any evidence of a warm interglacial period, and am unwilling to believe that there were more than one post-tertiary glacial periods, when one will explain all the phenomena; but if it were to turn out that the lower boulder clay does exist beneath the brick clays at Hoxne, it would be one of the strongest facts in its favour yet brought forward.

I now come to the real point and object of this paper. We have in England, at Hoxne, one of the finest opportunities known to exist anywhere in Europe of determining the true relation that the beds containing remains of palæolithic man and the great extinct Mammalia bear to the glacial period; yet we have been content for more than a dozen years to allow the age of the beds that underlie these deposits to remain a conjecture, and to accept a theory instead of ascertaining what are the true facts of the case. The geological world has been taught to believe that a question was settled that is not settled. We do know the age of the Hoxne deposits: they may, as held by Prof. Prestwich, be post-glacial; or they may, as held by Messrs. Croll and Geikie, be inter-glacial; or, lastly, they may, as I hold, be pre-glacial.

It is not creditable that this uncertainty should remain when it can easily be cleared up. A few shafts or bore-holes put down would soon determine whether or not glacial beds underlie the dark clays of the brick-pit, or sands and gravel underlie the boulder clay on the other side of the brook. Excavations should also be made around the spot where Mr. Frere made his discoveries, to ascertain the exact position in which the flint implements were found so abundantly. I feel satisfied that if Sir Edward Kerrison, to whom the property belongs, were applied to by any of our learned societies, he would willingly allow the necessary excavations to be made. Probably the expenditure of two hundred pounds would be amply sufficient, and I submit that it is a work that should be undertaken by the Royal Society or the British Association, who make grants for scientific enquiry.

II. A SCHEME OF WATER-SUPPLY FOR VILLAGES, HAMLETS, AND COUNTRY PARISHES OF THE CENTRAL AND EASTERN COUNTIES.*

By Prof. Hull, M.A., F.R.S., F.G.S.,
Director of the Geological Survey of Ireland.

THAT the development of zymodic diseases in villages and rural parishes is due to "dirt,"—which, as Lord Palmerston defined it, is "matter in the wrong place,"—and also to bad water, is an axiom that is accepted as soon as stated.† Few, however, except those whose lives are passed in such localities, are aware to how large an extent these preventible diseases are prevalent, even in places where beneficent Nature has granted all the necessary aids to health. The stagnant pool, the pestilential manure-heap, the odoriferous ditch, are but too frequently the immediate surroundings of a cottage or farmstead; and in the midst of these, or near thereto, is often planted the pump for the water-supply of the household, which, with the purer underground waters drawn from wider areas, again brings to the surface some proportion of the percolating filth.

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* Read before Section G at the meeting of the British Association at Bristol.

† Such diseases as typhoid, enteric, or filth fever, diphtheria, diarrhœa, dysentery, &c., arise from the use of polluted water. See on this subject an able paper by Mr. Jabez Hogg, on "River Pollution" (Journ. SocArts, 1875).

When a deep well or a pump is absent, the water for household use is often drawn from still more objectionable sources. These may consist of shallow pools, hollowed out by the side of the lane or road, along which an intermittent stream of surface-water trickles, liable to receive natural or artificial impurities from the adjoining field or road. If the pool (dignified by the name of "well") be not in direct surface-communication with the ditch aforesaid, yet is it indirectly supplied by the percolation of the water through a few feet or inches of soil, which after a time becomes so thoroughly saturated with filth, that it ceases to act as a filter for the finer and less palpable varieties of noxious matter; and these, as is well known, are the causes of greatest injury to health, and the most fruitful sources of disease. When neither of the above means of water-supply are in use, recourse is sometimes had to the adjoining brook, supplying water of varying quality, but which is at present under no supervision for the prevention of the influx of matter of a noxious character. On the other hand, where the geological conditions permit, many villages and hamlets are supplied with water from perennial fountains or deep wells, which, drawing their waters from wide areas of strata through which the rainfall has percolated by the natural process, have thereby become suited for use. In the early planting of these islands such fountains were generally selected as the sites of hamlets or homesteads, and many of these remain to the present day along the borders of the Chalk, the Lower Greensand, and the Oolites; while within the area of the London basin—as Prof. Prestwich has pointed out—many of the suburban villages near the city of London were grouped around a spring of water, or bed of gravel from which water could easily be drawn by shallow wells.*

Before entering further upon the subject of this communication, I wish to premise that I have no intention of dealing with the question of water-supply to large towns, or any of those places which would come under the head of "Urban Sanitary Districts" of the Public Health Act of 1872. Such districts and towns may well be relegated to the care of their respective sanitary authorities, guided by a corps of engineers, who are ever ready to find water if only the money for the purpose is forthcoming. It is to the more humble and greatly neglected villages, hamlets, and country parishes of the central counties my observations are intended to apply, with a view of showing that the means are generally available for providing them (where required) with that essential concomitant to health, decency, and comfort—good water.

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* Anniv. Address Geol. Soc. Lond., 1872.

Physical Considerations.

Though large portions of those districts of England referred to in this paper are destitute of hills,—the birth-places of springs and fountains,—yet it happens that the geological formations are arranged so as to constitute underground reservoirs for a large proportion of the ordinary rainfall, which can be rendered available by wells of greater or less depth. These districts are composed of the Mesozoic (or Secondary) formations, consisting of alternating beds of permeable, or water-bearing, and impermeable, or dry, strata; generally arranged with such a moderate dip as to spread over large areas, and capable of retaining on the one hand, or throwing off on the other, a certain proportion of rainfall, varying in amount according to circumstances.

The water-bearing strata consist of sandstones and limestones of various kinds; the impermeable, or non-water-bearing, of clays and shales; and it is therefore evident that any system of water-supply applicable in the one case would not be so in the other, and that the subject divides itself into two heads accordingly.

Let us, however, before proceeding further, take a rapid view of the formations referred to in descending order, commencing with the Lower Tertiary strata of the London Basin, which form the upper limit of our survey.*

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* The supply of the London district and the water-bearing strata of the Thames Valley, which is beyond the scope of the present paper, has been admirably treated by Prof. Prestwich, in his Anniversary Address to the Geological Society of London (1872), to which the reader is referred. See also "Horizontal Wells," by J. LUCAS, F.G.S., containing a remarkable and original scheme of water-supply, by intercepting the underground waters by tunnelling. Also, "Sixth Report of Commissioners on the Pollution of Rivers, and the observations thereon," by Mr. JOHN EVANS, F.R.S. (Quart. Journ. Geol. Soc., vol. xxxii., p. 115).

GEOLOGICAL FORMATIONS OF THE CENTRAL AND S.E. COUNTIES.

THICKNESS IN FEET.

	Formations.	Permeable Strata.	Impermeable Strata.	Quality of Water.
1.	*London Clay*	—	150 to 280	—
2.	Lower Tertiary (sands and pebble beds)	70 to 100	—	Soft.
3.	Chalk	645 to 1000	—	Hard.
	Upper Greensand	100 to 400	—	Rather hard.
4.	*Gault Clay*	—	130 to 200	—
5.	Lower Greensand*	20 to 500	—	Soft & good.
6.	Purbeck and Portland beds	0 to 60	—	Rather hard?
7.	*Kimmeridge Clay*	—	300	—
8.	Coral Rag and Grit	40	—	Rather hard.
9.	*Oxford Clay*	—	350 to 400	—
10.	Great and inferior Oolites	200 to 450	—	Hard.
	Upper Lias Sands	20 to 200	—	Soft?
11.	*Upper Lias Clay*	—	30 to 300	—
12.	Marlstone, or Middle Lias	30 to 250	—	Rather hard?
13.	*Lower Lias Clay*	—	500 to 600	—
	Keuper Marls (Trias.)†	—	600 to 3000	Gen'ly imper.
14.	Lower Keuper Sandstone‡	150 to 450	—	Soft.
	New Red Sandstone (Bunter)‖	0 to 2150	—	Soft or variable.
	Lower Permian Beds (alternating characters)	Variable.	Variable.	Soft.

Thus out of the fourteen sets of strata arranged in the above table according to their water-bearing qualities, there are eight which are permeable, viz., (2) the Lower Tertiary Sands, (3) Chalk and Upper Greensand, (5) Lower Greensand, (6) Purbeck and Portland beds, (8) Coral Rag and Grit, (10) Oolites and Upper Lias Sands, (12) Middle Lias, (14) New Red Sandstone, with a total thickness varying from 1275 to 5600 feet; while there are, alternating with the above, six sets of strata which are impermeable, viz., (1) London Clay, (4) Gault Clay, (7) Kimmeridge Clay, (9) Oxford Clay, (11) Upper Lias Clay, (13) Lower Lias and Keuper Marls, with a total thickness varying from 2110 to 5030 feet vertical.§

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* The Lower Greensand of Surrey consists of several members of varying hydrometric qualities, for an account of which see "Geology of the Straits of Dover," by W. TOPLEY, F.G.S., and "Horizontal Wells," by W. LUCAS, p. 21.

† The beds of Keuper Sandstone about the centre of the marls often contain water. In the Scarle boring, a feeder of water yielding 11 gallons per minute was struck in these beds, at a depth of 790 feet.

‡ In Scarle boring, about 250 feet thick.

‖ Scarle, 540 feet.

§ I have purposely omitted the clays and gravels of the drift-series, as they are of so variable a nature that no general rule can be laid down regarding their water-bearing qualities. The boulder clay is, however, a generally impermeable stratum, and the middle sands and gravels, water-bearing; from these springs of good soft water often issue forth.

Qualities of the Waters from the Permeable Strata.

In endeavouring to ascertain the qualities of the underground waters derived from different formations, it may be generally assumed that those drawn from limestone formations are "hard" and those from sandstone "soft." Owing, however, to variations in the nature of some of the strata in different localities, and to the greater or less proportion of carbonate of lime, carbonate of magnesia, or oxides of iron, &c., which they contain, the quality of the water from the same formation is liable to variation according to locality. This subject has already been so fully dealt with by various authors that I do not consider it necessary to do more than give a brief summary of the results as far as they have been ascertained in several localities.

Water from the Chalk.

From analyses of many wells and springs in this formation in the South-East of England, it is well known that "Chalk water" is hard, though clear and well-suited for many purposes, especially in the important one of brewing. The percolation of the rain through this formation, amounting to about one-third of the actual rainfall, is so exceedingly slow that the water has abundant time to take up a large proportion of carbonate of lime from the rock itself. The mode of percolation has been ably treated by Prof. Prestwich,* Mr. Clutterbuck,† Mr. Homersham, C.E.,‡ and others. It seems, from observations made on the Chalk hills by Mr. Beardmore,|| that it takes from four to six months for the rain to reach a depth of 200 to 300 feet, so that the water which is drawn from this depth in summer belongs to the rainfall of the preceding winter. The total quantity of solid matter in chalk water varies from 31 to 32½ in 100,000 parts, of which from 16·4 to 21 parts consist of carbonate of lime. In the case of large works this mineral ingredient can be dealt with by the softening process invented by Dr. Clark, but for country villages there seems to be no plan of easy application for lessening the amount of calcareous matter except that of boiling, by which the hardness is reduced from 24·7 to 3·7 in extreme cases.

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* Anniversary Address, 1872, p. 41.

† Proc. Inst. Civ. Engineers, 1842-3 and 1850.

‡ Report, Royal Commission on Water-Supply, 1869.

|| *Ibid.*, p. 204.

Upper Greensand.

The water from the Upper Greensand is probably a little less hard than that from the Chalk.

Lower Greensand.

The water from this formation is generally considered unexceptionable, and decidedly "soft." Samples taken from five localities give a mean result of 7·9 of solid matter in 100,000 parts of water. Mr. Bateman, C.E.,[*] speaks of the water from this formation in the basin of the Wey as being of the greatest purity; and, as the sands are generally loose and incoherent, they absorb nearly all the rain which falls on their surface, except that given off by evaporation or imbibed by vegetation.

Enormous quantities of water are absorbed by this formation, where, as in Surrey and Kent, it is largely developed; and to such an extent are they capable of being rendered available that Mr. Lucas proposes, by means of tunnelling, to render them available for the supply of London.[†] In Bedfordshire, Bucks, and Berks, as also in the S.W. of England, the formation attains large proportions, and contains bands of siliceous iron ore, which to some extent affects the water. Exposure to the air, however, causes the iron to be precipitated.

Oolite Limestones.

The waters from these formations are all more or less hard, yet less so than those from the Chalk, and of course where the source is the sandy strata which accompany the limestones of the Portland Oolite, the Great and Inferior Oolites, &c., the qualities of the water will be found to vary accordingly. Of the proportion of solid matter in the waters of the Oolites that found in the fine springs of South Cerney, near Cirencester, which rise along the line of a large fault, may be taken as a sample. The total amount of solid matter was found to be 18 grains per gallon, of which 1·25 was organic.[‡]

The water from the Seven Springs near Cheltenham, from the Inferior Oolite, gave 6 grains per gallon, of which 2 grains consisted of organic matter.

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[*] Report contained in a Return to an Order of the House of Lords, 1852, No. 258.

Horizontal Wells, by J. LUCAS, F.G.S. (1874).

[‡] Analysis, by J. HORSLEY, F.C.S. Appended to Report on the Water-Supply of Cheltenham, by Dr. WRIGHT, F.G.S.

[‖] *Ibid.* See, also, Prof. PRESTWICH "On the Geological Conditions affecting the Water-supply of Houses, &c." (Parker and Co., Oxford), 1876.

The well at Thames Head, pumping from the Great Oolite near Cirencester, gave 16 grains per gallon;* and the waters of the Chelt, above Charlton Mill, near Cheltenham, which rise from springs at the base of the Inferior Oolite, gave 20 grains per gallon, of which 4 grains consisted of organic matter.*

Marlstone, or Middle Lias.

I have no analysis of water from this formation; but, judging by the appearance of the numerous springs which issue forth from the flanks of the hills of Marlstone in the Midland Counties, it may be considered of good quality and moderately soft. In a formation so variable as the Marlstone—consisting in some places of calcareous sandstones, in others of ferruginous limestones passing into ironstone—the character of the water must be liable to considerable variation in different localities.

New Red Sandstone.

Next to the Chalk, the New Red Sandstone—including the Bunter and Lower Keuper divisions—is the most important water-bearing formation in the district under consideration, and the water which it yields possesses this advantage over that of the Chalk, that it is softer, and generally capable of being used for all domestic and manufacturing purposes. From the numerous analyses that have been made of these waters in different localities in the central and N.W. counties, we have the means of arriving at general conclusions on this subject, and for special and accurate details we may look forward with interest to the Reports of the Committee on Underground Waters, appointed by the British Association in 1874.† The beds of the Bunter Sandstone are wonderfully adapted both to act as natural filters and as reservoirs for that portion of the rain which sinks below the surface. This may be assumed at one-third of the actual rainfall as an average; while in some districts—where the formation consists of soft sandstone or unconsolidated conglomerate, devoid of a thick covering of drift clay—the amount of absorption must reach well nigh one-half the amount of rainfall. Owing, also, to its uniformity in composition, and the absence of beds of clay or marl of any importance, the whole mass of rock below a certain level, and throughout a depth of several hundred feet in some districts, becomes water-logged, and wells sunk therein do not (as in the case of the Chalk) generally depend for their supply on the presence of fissures, but water is nearly always found after the "water-level" of the immediate district has been reached. This was the view, since abundantly confirmed, taken by the late distinguished engineer Mr. Robert Stephenson, in his "Report on the Water-Supply of Liverpool," and has been acted upon with success by several engineers who have sunk wells for the supply of Liverpool, Manchester, Birmingham, Nottingham, and other towns in the northern and central counties.

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* HORSLEY'S Analysis, *sup. cit.*, p. 309.

† Belfast Meeting. First Report presented at Bristol, 1875.

The remarkable permeability of this formation, equalling probably that of the Lower Greensand both of England and France, has recently been illustrated by the deep boring in search of coal at Scarle, near Lincoln. This boring, conducted by the "Diamond Boring Company," was commenced in the Lower Lias in 1874, and, after having passed through 790 feet of these beds and the underlying impermeable marls of the Keuper, struck a feeder of water in the Lower Keuper Sandstone, and a still stronger one at 950 feet, which caused the water to spout up 5 feet above the surface. The whole of the Bunter Sandstone below was also charged with water, as proved by the increasing temperature down to its base of 1500 from the surface.* Now, the distance of this boring from the outcrop of the beds towards Mansfield varies from 12 to 16 miles, and through this distance the water percolated from a district 300 or 400 feet above the sea-level, till it reached a depth of about 900 feet below it; and, being kept down by the overlying impervious beds of the Keuper Marl, ascended to the surface with great force on being released through means of the borehole on the Artesian principle.

The amount of solid matter per gallon in the waters of the New Red Sandstone varies from 6 to 15 grains where they have been taken from wells not too shallow, or from those which are free from contamination by sewage pollution. It is to such a cause that the large proportion of saline and other ingredients in some of the Liverpool and Manchester wells, amounting in some instances to 24 and 36 grains per gallon respectively, is attributable. In general, the proportion of these ingredients occupies a central position between those of the Chalk and other limestone formations on the one hand, and the surface-waters of mountain districts composed of millstone grit or of Silurian rocks on the other. The following examples will probably be considered sufficient for the purpose here intended :—

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* From information kindly afforded by Mr. J. T. Boot, mining engineer, under whose superintendence the works were carried forward.

	Wells or Springs.	Grains per Gallon.
Liverpool District*	Bootle	24·00
,, ,,	Soho	24·80
,, ,,	Windsor	23·22
,, ,,	Green Lane	13·60
Birmingham†	Aston	12·82
Stourbridge‡	Well of W. W. Co.	21·95
Leek (Staffordshire)‖	Wall Grange Spring.	12·26
Whitmore (near Crewe)§	Well of L. & N. W. Ry.	6·10
Parkside (nr. Warrington)¶	Well	11·12
Nottingham	Several wells (suburban)	12·0 to 16·0

As an illustration of the effect of the percolation of saline matters on the waters of even deep wells in large towns, I give here the analysis of the waters of a well from the south side of Manchester, made in 1865, by Dr. Angus Smith, F.R.S. This will show the desirability of having all wells as far as possible removed from such sources of contamination.

Water from Well, Manchester, South Side.

	Grains per Gallon.
Chloride of sodium	4·88
Sulphate of soda	7·33
Carbonate of soda	7·35
,, of lime	9·77
,, of magnesia	5·29
Phosphoric acid, potash	traces
	34·65

Lithia discovered by spectroscope.

On the other hand, the purity of the waters from the Aston Well, the Wall Grange Spring (yielding 3,000,000 gallons per day), the Whitmore, Parkside, and Nottingham Wells,—which are removed from the influence of populous neighbourhoods,—must be considered as completely establishing the excellence of this source of water-supply.

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* Analyses by Richard Phillips, F.C.S.

† Analysis by Dr. Hill, F.C.S.

‡ Supplied by Mr. E. Bindon Marten. This well is only 46 feet deep.

‖ Analyses by R. Phillips.

§ This well supplies the works and populace of Crewe, and was sunk, on the recommendation of the author, by the London and North-Western Railway Company, 1864.

¶ Analysis by Dugald Campbell, F.C.S.

Considering, therefore, the wide extension of the water-bearing strata of the New Red Sandstone, the excellence of the formation as a source of pure water,—equally cool and refreshing in summer and winter,—it must be conceded that the central counties are happily situated as regards their prospects of water-supply, provided these resources are judiciously utilised. Nor must it be forgotten that the internal reservoirs do not terminate with the upper boundary of the sandstone, but that the waters pass for great distances under the overlying impervious marls, as illustrated by the case of the Scarle boring, and that, by deep wells or borings, these underground reservoirs may be converted into perennial fountains.*

Application of the above Observations to the Cases of Villages and Hamlets.

From what has been stated it will be obvious that for those villages, hamlets, or parishes situated on any of these water-bearing strata, or not far from their *upper margins*, where they pass below the overlying impermeable formations, wells are the proper and available means of supply. But the determination of the question regarding the character of the formation underlying each special village or hamlet, as well as the selection of the best site for a well, are evidently geological questions, requiring some special knowledge of this branch of science; and the problem how such knowledge is to become available in each case remains for solution. To this I now address myself.

In the first place it will be admitted that the completion of the maps of the Government Geological Survey, over the districts comprised in this paper, places them in a very advantageous position for availing themselves of the underground waters stored up in the strata. Until some accurate and detailed maps such as these were rendered available, the data for arriving at definite conclusions regarding the geological situation of many localities could not be obtained; and constituted sanitary bodies might well have hesitated to accept advice from amateurs, of whose mode of observation and process of reasoning they were generally ignorant. But the maps of the Geological Survey, published under the authority of a Public Department, and showing the limits of the water-bearing and impervious formations laid down with the greatest attainable accuracy, furnish ready to hand all the data for determining the preliminary questions. With these maps a Sanitary Board ought to be able, with very little assistance of a technical kind, to determine whether a particular village or hamlet, requiring good water, was so placed geologically as to be able to obtain a supply by means of a well; and, if so, also the best spot in which such a well should be sunk.

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* Thus at Retford, Notts, which stands on the upper beds of the Keuper marl, not far below the base of the Lias, there are two wells sunk down 600 feet into the New Red Sandstone for the supply of two large breweries, and the water rises within 6 feet of the surface. One of these wells was sunk under the direction of Mr. John T. Woodhouse, F.G.S., of Derby.

I am aware, however, of the unhappy and prevalent ignorance of even the most rudimentary principles of geology amongst such bodies, and it would therefore be necessary—for the proper carrying out of the proposals here suggested—that an experienced geologist should be attached to the staff of the Central Board of Health in London, whose duty it should be, when applied to, to afford advice in all cases of this kind. Owing, therefore, to the progress of the Survey over the districts here alluded to, it seems to me that the time has arrived for putting in force some scheme of general application depending on geological considerations.

Cases not admitting of Supply by Means of Wells.

I now come to the case of those villages, hamlets, or parishes which, owing to their geological position, cannot be supplied by means of wells. These are they which are situated on such impermeable strata as the Oxford Clay, the Lias or the Keuper Marls, or are at such a distance from the subjacent water-bearing strata that the depth of a well would be great, and the expense too costly for the resources of the inhabitants. In such cases a supply from surface drainage of some available brook or rivulet seems the only resource; and powers should be given by the local sanitary authority to impound such stream in small reservoirs, under proper and stringent regulations, so as to prevent surface pollution of the water either in the stream or in the reservoirs. The construction of such small reservoirs as would be necessary for the purposes here alluded to would entail only a moderate amount of engineering skill and of pecuniary outlay. In providing pure water it would also be necessary to stop up or destroy all impure wells, pools, or tanks, in the same village or hamlet, as the poor are very apt to prefer a source of supply to which they have all along been accustomed.*

Machinery for carrying out a General System of Water-Supply for Villages and Hamlets.

We come now to the difficult question as to the machinery for carrying out such a system of water-supply as is here proposed; and perhaps the first step to be taken is to ascertain to what extent the evil of insufficient or polluted water-supply prevails in country places.

This, I think, might be effected by means of the agency evoked under "The Public Health Act of 1872." Under the clauses of that Act the Rural Sanitary Authorities have the power of appointing a Medical Officer of Health and an Inspector of Nuisances for a period of five years; and it would probably not be difficult, by their co-operation, to obtain returns from all the parishes included in the rural sanitary districts, together with the villages and hamlets contained therein. I would propose that a simple form of circular be drawn up by the authority of the Local Government Board, which the officers above named should be required to fill up and return, stating—1st. The names of the villages or hamlets in each rural sanitary district. 2nd. The number of houses. 3rd. The existing mode of water-supply. 4th. The opinion of the medical officers regarding the nature and quality of such water, if any there be. And 5th. Observations regarding the general health of the inhabitants, and the presence of zymodic diseases.

It would then be the duty of the Local Government Board to eliminate the names of those villages or hamlets in which it would appear, from such returns, that the water-supply was sufficient, both as regards quantity and quality; and then would remain those residuary cases requiring to be dealt with under the scheme here proposed. They would probably be found to amount to several hundreds within the limits of the area dealt with in this paper.

It would doubtless be advisable, in carrying out such a scheme, that the existing parliamentary powers should be called into requisition. After perusing "The Public Health Act of 1872," it seems to me that with slight modification that Act might be made available. The division of the whole country into (1) Urban and (2) Rural Sanitary Districts is excellent, and at once determines the districts outside, and within, the scope of the proposals I have ventured to offer. The appointment of Medical Officers of Health by the Sanitary Authorities, but who are responsible to the Central Authority in London, offers an effective agency. Under Clause 17 the Rural Sanitary Authority has power to provide a supply of water for "Rural Sanitary Districts," but such districts are, I fear, too extensive for such modes of water-supply as is here proposed, and it would be necessary to split them up into villages and hamlets, having independent powers, though the necessary expense might be spread over each district.

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* Such power is granted to the Local Sanitary Authority under the Act of 1874.

I would therefore propose that when it is found, from the Reports obtained through the Rural Sanitary Officers, that the supply of water to any village or hamlet is insufficient or impure, the Sanitary Authority of the district in which the village or hamlet is situated should be required to proceed forthwith to apply the remedy. It would be necessary then to have recourse to the Geological Survey maps to ascertain whether the locality could be supplied by a well, and if the local technical acquirements are insufficient to settle this question, the aid of such a Government officer as has been already referred to should be afforded; while at the same time it should be competent for the Sanitary Authority to call in professional advice from any other quarter.

A well having been determined upon when the geological conditions prove favourable, the site fixed with reference to local circumstances, and the cost having been ascertained, powers should be granted to raise money for carrying out the work and rendering the well available for the free use of the whole of the inhabitants.

In sinking such a well, the top waters—to a depth of 10 or 12 feet—should always be carefully stopped off by solid masonry; and means be adopted for keeping it free from contamination, under stringent regulations and heavy penalties. Being for the use and benefit of all, it should be jealously guarded by all as a public benefactor.

I have not considered it necessary to enter at length into the means by which my proposals should be carried out. These are matters of detail, capable of easy settlement by those who are conversant with such matters. I have contented myself with sketching out a plan of general application, which will probably be considered sufficient for the present occasion.

By one or other of the above methods probably all the villages or hamlets of the Central and Eastern Counties which require it might be supplied with pure water. Till this is done it cannot be considered that we have reached the state of sanitary improvement befitting a great and prosperous country.

Postscript.—Since the above was written I have had an opportunity, through the courtesy of Mr. Sclater-Booth, M.P., the President of the Local Government Board, of perusing a copy of the Public Health Act of 1874, which appears to me admirably calculated to meet the case of the districts referred to in this paper, and to provide the machinery by which the suggestions here offered might be carried out.—E. H.

III. VIVISECTION.

MYSTERIOUS and perplexing are the ways of modern Humanitarianism. One moment it swallows the largest of camels, and the next it strains at the tiniest of gnats. With unfaltering step it marches over the summit of Mount Everest, and then stumbles at some scarcely visible mole-hill. To drop metaphor, it fastens upon matters never demonstrated to be evils, minute in their amount and unobtrusive in their character, whilst practices much more questionable in their nature, and almost world-wide in their extent, are allowed to pass unchallenged. Perhaps, however, there is method in this seeming madness. Sport and Fashion are popular and powerful, and may therefore—to quote a somewhat cynical proverb—" steal a horse" with impunity, whilst Science, weak and uninfluential, " is hanged for looking over the gate." This may perhaps, in some degree, explain the recent raid made upon vivisection. But if Humanitarianism is cautious as to whom or what it attacks, when it has once selected a victim it is equally pertinacious and unscrupulous. It never retracts, never owns itself mistaken. We have heard that there is no animal, not even a *Galeodes*, so aggressively pugnacious as an advocate of " international arbitration ;" none so narrow-minded and selfish as the professed cosmopolitan ; and, in like manner, it might be said that of all enemies the most bitter, vindictive, and unchivalrous is the humanitarian. There is with him no toleration, no agreement to differ. " Be my brother or I must kill you" is his motto, and too often, if unable to overcome his opponents in argument, he assails their private characters. Now when "world-betterers" combat any real evil—of which there is a tempting assortment awaiting their attention—this fanatical zeal may sometimes do good service; but when they seek to fetter the development of Science, and thereby to check the progress of the world, they must be encountered by a determination as stern as their own. Whilst scorning to borrow their unfair weapons, and whilst giving them full credit for sincerity of a certain kind,—a credit which they have to share with Thugs and Inquisitors,—we must refuse to concede even a hair's-breadth of their demands. We know that certain accusations are supposed to require no evidence, and that to defend the accused is an invidious task. Such was in former ages the case with charges of heresy and witchcraft; so it is now with charges of cruelty to animals. Yet though certain to be misrepresented, we must proclaim the outcry raised against vivisection to be the outcome of misconception and inconsistency.

We will first examine the cases in which man claims the right to inflict pain upon the lower animals. Of these there seem to be five classes, namely—

1. In self-defence.
2. In order to obtain articles of real or supposed necessity.
3. In compelling animals to obey his will.
4. In the pursuit of amusement.
5. In the pursuit of knowledge.

The pain thus inflicted may vary in degree from slight uneasiness, or from a momentary shock, to intense and prolonged torture. It includes terror, distress, and exhaustion, as well as the direct action of mechanical or chemical agents upon the victim. It includes death, for—except by the use of certain narcotic poisons—death cannot be induced without some kind of pain. These different cases we will now consider, enquiring if, and in how far, man is justified in the line of conduct which he generally, if not universally, adopts towards his "poor relations." We shall not seek to cut asunder the knot by the assumption that animals, even the lowest, are utterly incapable of feeling,* or by declaring, with Prof. Mivart, that, though sentient, they are unconscious of their feelings, like a man under the influence of chloroform. On the contrary we will, for the present, take it as proven that animals both feel and know that they feel.

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* Lamarck grouped together certain of the lower forms of life as "*animaux apathiques*." We doubt whether even vegetables are absolutely incapable of feeling.

We turn to our first case, the infliction of death, and consequently of pain, in defence of our persons and property. In virtue of that struggle for existence which, whether "Darwinism" be true or false, is an acknowledged fact, one species can only exist at the cost of others. There are beings—too many to be here enumerated—which, directly or indirectly, seek to make man their prey. From the lion, the tiger, the cobra, or the shark, down to the flea, the mosquito, the *Lucilia hominivora*,[*] the *berne*, the tape-worm, the *Trichina*, and even to those microscopic beings which are now believed to be the propagators of pestilence, we are attacked in our persons by an incalculable horde of enemies. At the same time we have indirect assailants scarcely less formidable. The rat, the mouse, the locust, the mole-cricket, the potato-beetle, weevils, flies, and slugs of many kinds, seek our destruction by the process of destroying our means of subsistence. We have, therefore, simply the alternative placed before us to kill or to be killed. We have so far—with the exception of certain Oriental fanatics—elected the former alternative, and with bullets, traps, poisons, medicines, and appliances of the most varied kinds, we wage war alike against wild beasts, vermin, Entozoa, and disease-germs. So far our humanitarian zealots have discovered no wickedness in this struggle, and have not yet proposed to substitute "arbitration" as a means of dealing with "man-eaters." This, we presume, is a pleasure held in reserve for posterity.

We may therefore assume that the right to exist involving the right to kill, and it being generally impracticable to kill without causing pain, man has the general right to inflict pain upon the lower animals where his well-being requires, the conditions being that such pain shall not be wantonly and unnecessarily inflicted, and shall be minimised both in its degree and duration.

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[*] Van Beneden's "Animal Parasites and Messmates"—a work which might have been expressly written as the *reductio ad absurdum* of the old Natural History—contains the following notice of this detestable vermin;—"Vercammer, a military surgeon of the Belgian army, relates that a soldier in Mexico had his glottis destroyed, and the sides and roof of his mouth rendered rugged and torn, as if a cutting-punch had been driven into those organs. This soldier threw up with his spittle more than two hundred of the larvæ of this insect." Yet the author opens his subject with the following passage, conceived in the true spirit of Cuvier, or of the Bridgewater Treatises:—"In that great drama which we call Nature each animal plays its especial part, and He who has adjusted and regulated everything in its due order and proportion watches with as much care over the preservation of the most repulsive insect as over the young of the most brilliant bird. Each as it comes into the world thoroughly knows its part, and plays it the better because it is more free to obey the dictates of its instinct." The idea of a being whose "especial part," divinely adjusted and regulated, is to destroy the glottis of man and to punch holes in the roof and sides of his mouth, is somewhat suggestive.

The second case, the destruction of animal life in order to obtain desired articles, is in its extent inferior only to the one just mentioned, and much more heterogeneous in its nature. Man kills animals to subsist upon their flesh, and even the most rigid vegetarian must admit that in high latitudes he has no other option. Here, then, as in the first case, the infliction of pain is a matter of absolute necessity. In temperate and tropical climates the circumstances are different. Here vegetable food is procurable in sufficient quantity for the support of life. Still the experience of the vast majority of men leads them to believe—and to act upon the belief—that a diet composed in part, at least, of animal matter, is most conducive to their vigour, health, and comfort. Hence we find that, except vegetarians, all mankind believe themselves justified in inflicting death, and consequently pain, upon the lower animals, not merely at the biddings of absolute necessity, but at those of convenience; law and public opinion stipulating merely that no amount of pain shall be inflicted beyond what is clearly necessary to the object in view. This, as we shall further find below, is an important conclusion.

But man takes life for many other purposes than for mere food: he desires hides, horns, furs, feathers, ivory, animal fats and oils, and considers himself fully justified in satisfying these desires, however extreme or whimsical, by the destruction of life. The savage, in need of clothing and unable to manufacture woollen garments, may indeed plead the necessity of wrapping himself in furs; but can civilised man, who is well acquainted with the art of producing artificial coverings equal if not superior to furs, advance the same plea? All that he can say in justification of his practice of killing and torturing, in order to obtain furs and feathers, is to proclaim that not his necessities, not his convenience or well-being, but his luxuries, whims, and caprices are a full warrant. It may be here useful to glance at the seal-skin trade as an instance in point. Till a comparatively recent period seals were hunted merely for their flesh and blubber, by Greenlanders, Esquimaux, and occasionally by whale-fishers from civilised nations: their skins were in little demand, being unattractive in colour. Unfortunately for the seal, and it may be added unfortunately for the honour of humanity, a method was discovered of converting the greyish hue of its fur into a rich lustrous brown. Forthwith seal-skins became the rage, not for the caps or waistcoats of sailors and fishermen, or the garments of Skrælings, but for the jackets of fashionable ladies, and found a ready sale at high prices. To obtain them extensive hunting expeditions were sent out, and conducted with an amount of cruelty which is perhaps without a parallel in all the dealings of man towards the lower animals. Seals are most readily captured at the time when they have young cubs not yet capable of following their mothers through the water. At this time they may be found upon the shores of certain arctic regions in great numbers, and here accordingly they are attacked. The mother seals are stunned with blows from clubs, and then flayed, often before quite dead, it being considered that the fur is thus obtained in a more lustrous condition. As for the young ones, they are left to perish of cold and hunger. The frightful atrocity of this system will be more fully understood if we remember that the seal stands high in the scale of animal life, and possesses a large well-developed brain and a delicate nervous system. All this cruelty is therefore done for the sake of " fashion," and to it all wearers of seal-skin jackets make themselves accessories. It is true that some voices, in England and elsewhere, have been raised against this system, and that some attempts have been made to mitigate its horrors by legislative enactments. But policemen, officers of the Society for the Prevention of Cruelty to Animals, and magistrates, cannot follow every seal-hunting expedition to the northern seas; and there is every reason to fear that as long as the demand for seal-skin jackets continues, the supply will be obtained substantially in the manner we have sketched.

Feather beds are no longer, as was once the case, considered preferable to all others. But they are still in extensive use, and live goose feathers—*i.e.*, such as are plucked from the unfortunate birds whilst still living—are still preferred as being more elastic than those obtained after death. Whether this practice is legal at the present day we know not. But a demand exists for such feathers, and they are still advertised for sale, no one denouncing such needless cruelty.

Somewhat similar must be our conclusion concerning the present mania for using portions of birds, or even entire birds, as ornaments. In consequence of this whim rare and beautiful birds, trogons, sun-birds, humming-birds, birds of paradise, and others, are shot down at random, and are imported not as formerly, in occasional specimens for museums, but literally in heaps. We do not mean to say that these birds are subjected to such prolonged tortures as are the seals. They are shot with the gun or the blowpipe ; but their nestlings are often left to die of hunger, and, above all, their lives are taken wantonly and needlessly. That most of the species so persecuted are insect-feeders, and consequently the friends of man, is an aggravation of the case. We love consistency, and therefore feel bound to record the fact that one of the foremost agitators against vivisection has also denounced the practice of using birds as materials for the milliner and the *modiste*. Summing up the second case, we may say that whenever man finds any portion of the body of an animal saleable he thinks himself justified in procuring it by the infliction of pain and death, with little regard either to the urgency and importance of the demand thus gratified or to the exact nature of the means employed in obtaining a supply. The buyer, on his part, seems fully satisfied that his whims are of paramount importance.

We pass next to the third case. Man makes use of the services of certain domestic animals, and in training them for various purposes, and afterwards in the execution of such purposes he inflicts upon them a considerable amount of pain. It is not to be expected that horses, asses, camels, &c., will of their own accord carry burdens or draw weights. Man, therefore, has recourse to compulsion. Here, as in the former cases, the pain inflicted varies very greatly in degree, which of course does not affect the principle involved. We must here point out that though the services of such animals are a very great convenience, they are not absolutely necessary. Mexico, before the Spanish conquest, was an instance of a civilisation without beasts of burden. Hence, therefore, all persons who—whether directly or indirectly, whether habitually or occasionally—make use of beasts of burden, declare, in fact, that they are justified in inflicting pain upon animals whenever it may suit their convenience. Under this case must also be included painful operations practised upon brutes to render them more subservient to man, more fit for his purposes, or more in harmony with his caprice. The docking to which the tails of horses were subjected in the earlier part of the present century is an instance of this nature. Here, too, belongs the use of the bearing-rein, condemned indeed by a vast majority of those who claim to speak with authority upon such topics, but still very widely practised, and not likely to meet with legislative interference.

Man, in the fourth place, inflicts death and pain, bodily or mental, as a mere pastime. So common is this that, even amongst a people so ostentatiously virtuous as ourselves, more perhaps than among nations who make less boast of moral pre-eminence, "amusement," or its synonym "sport," is supposed to involve almost of necessity the taking of life. It is perfectly true that many of the pastimes of former ages which turned solely upon man's love of inflicting or of witnessing pain have been abolished. Gladiatorial shows, combats of wild beasts, bull and bear baiting, and pugilistic encounters are no longer tolerated; but cock-fighting seems to be experiencing a revival, the offenders, when detected, meeting with but very trifling punishment. The distinction, moreover, between what is punished as cruelty and what is tolerated—or rather applauded—as "sport" is at times very evanescent. Thus to course hares or rabbits in an enclosed place is "baiting," and as such subjects all concerned in it to the correction of the law. To do the very same thing in an open tract of country is "sport," and involves neither legal nor social penalties. Yet the only difference is that in the former instance the animals pursued have some small chance of escape. But that their terror is less when fleeing, or their sufferings smaller when caught, no one can maintain.

It is, indeed, contended on behalf of the chase, as practised in England,—*i.e.*, where an animal is hunted not in order to get rid of a nuisance or a danger, nor for the sake of obtaining its flesh or other valuable portions for use—that the real object is not so much amusement as health and the cultivation of certain manly virtues which a free nation cannot afford to let die out. We are willing to accept this plea in the utmost reasonable extent. Still we may ask whether health might not be as well secured by botanical, geological, artistic, or antiquarian rambles in moorland and forest as in shooting or fishing expeditions? The question might further be put—whether the manly virtues referred to may not be quite as advantageously cultivated in the destruction of beasts really dangerous to man, and which are still to be found in plenty, if not in the home kingdoms at least in other provinces of the empire? But whilst we freely admit that courage, endurance, hardihood, are required in and developed by fox-hunting, deer-stalking, grouse-shooting, and the like, can this be said in favour of the prosaic massacres of sparrows, pigeons, and half-tame pheasants? Were we not aware that inconsistency is one of the most striking attributes of human nature we should declare that the nation which can tolerate Hurlingham, and yet raise an outcry against vivisection, must be the very focus of hypocrisy.

We now come to the last case. A small amount of life is sacrificed and a small amount of pain is inflicted in the pursuit of knowledge. Singularly enough this occasions a greater outcry than any of the former cases. We come, then, to the singular conclusion that it is permissible to kill animals, and to inflict pain upon them, for our safety, for emolument, convenience, luxury, ostentation, or amusement, but not for the acquisition of knowledge! Surely such a proposition, if once fairly stated, carries with it its own refutation. But the knowledge sought for and acquired by means of vivisection is not for the mere gratification of our curiosity: it has already thrown most valuable light on the preservation of health, the prevention of disease, and the consequent prolongation of life. Hence it may be said that the animals submitted to vivisection are indirectly, indeed, but not the less decidedly, sacrificed to our safety. If we may not destroy life for our safety, what right have we to take it for any purpose less urgent? Therefore we maintain that no person who kills animals, or causes them to be killed or subjected to pain for any purpose whatever, or derives any benefit from such death or infliction of pain, is logically justified in denouncing biological experiments. But some opponents may urge that what they object to is not the mere death of a few animals, but the excessive and prolonged torture to which they are previously exposed. We reply that if it is once conceded that we may under certain circumstances inflict pain upon animals, provided that we have a worthy and important end in view, the precise amount of pain is no longer a question of principle. Surely for an end so important we may take means which would be unjustifiable if our purpose were merely to compel a refractory beast to obey our will or to minister to a frivolous passion for ostentation and display. The pain inflicted in vivisection is much smaller in the number of cases, and certainly not more intense or prolonged in any one case, than that to which animals are subjected for other and less important ends. We may be told that one wrong does not justify another; but may we not bid the agitators take the beam out of their own eye before they seek to remove the mote from ours. When anglers and coursers, *battue*-sportsmen, Hurlingham-heroes, and wearers of seal-skin jackets presume to denounce vivisection, their only right is that of impudence.

It must be remembered that biologists, far from inflicting pain needlessly and wantonly, or from taking any pleasure in its infliction, seek, by every device conceivable, to minimise the sufferings of the animals operated upon. The smaller the shock given to the subject, and the less its normal condition is affected in anything beyond the exact point at issue, the more trustworthy will be the result. The biologist, therefore, who should inflict any needless or avoidable torment on the animals experimented upon, would simply defeat his own object. It is important here to remember that, according to the Report of the "Royal Commission on Vivisection," the Secretary of the Society for the Prevention of Cruelty to Animals frankly acknowledges that he does not know a single case of wanton cruelty. Surely if such an admission is made by the responsible official of a powerful and influential organisation, with abundant means at command for probing the matter to the very bottom, and spurred on to action by a sensational outcry, we shall be warranted in assuming that no such cases exist.

Is it, then, rational to attack what is thus confessed to be free from "wanton cruelty," so long as in other directions so much wanton cruelty exists?

It is urged that vivisection must have a degrading and brutalising effect on all who are engaged in it. Such a result, they urge, would be especially deplorable in the case of medical practitioners, who should be eminently humane and sympathetic, if their services are to be acceptable to the suffering.

Had we to deal with ordinary opponents we should challenge them to produce an instance of the "degradation" of which they speak. We should point to illustrious men, living and dead, who have enlarged the territory of biological science and the resources of medical art by experiments upon living animals, and should ask them if the humanity of these men had been or could be called in question? But we fear that the anti-vivisectionists would, in answer to our challenge, "evolve out of their own consciousness" charges of cruelty. Such calumnies would, indeed, ultimately find their level, but we cannot make ourselves a party to carrying the war into the sacred sphere of private life.

There is, of course, a surface plausibility in the notion that the practice of vivisection must render men generally inhuman; but on closer examination it fades away. The biological experimentalist inflicts pain upon animals for one important end only, regarding it all the time as an unpleasant necessity. Where this end does not come into view he has no temptation to use the means.

It may be said that men can by habit become blunted to the exact nature of what they do, see, or experience. This is true, but the blunting process is special, not general. A man long inured to some particular form of danger, and grown indifferent to that one form, may be nervous, or even timid, if suddenly exposed to some novel peril. We have heard of reckless miners—accustomed to open their safety lamps in a fiery vein, and to calmly smoke their pipes over a keg of gunpowder—displaying no small trepidation if out at sea in a moderate breeze. Precisely in the same manner men accustomed to inflict pain or death upon one particular class of animals are not necessarily, on that account, blunted to the sufferings of other brutes, and still less of their own species. Fishermen, butchers,* poulterers, are by no means more inhuman or ferocious than other persons of similar position in life and degree of culture. Sportsmen and anglers cannot, certainly, as a class be accused of general and habitual brutality. Some of them are even zealous and distinguished philanthropists. Why, then, should it be asserted, without a tittle of evidence, that medical men who have practised vivisection, or who have made any experiments upon living animals, must be rendered callous to human suffering? Inflicting pain, as they do, more rarely than the classes of men above-mentioned, and for the highest purposes only, it is extremely unlikely that such a result should ensue; and in the absence of affirmative facts, which had they existed would have been trumpeted through the length and breadth of the land, we must dismiss this argument as idle and frivolous in the extreme.

In proof that great respect for animal life does not necessarily involve reverence for the superior sanctity of human life, we may refer to the sect of the Jains, generally supposed to be an offshoot of the Buddhists, and still numerous in some districts of India. Some of their priests never sit down without previously sweeping the spot, lest they might crush out the life of some creeping thing. They refuse to eat in the dark, as they might possibly swallow an insect, and thus destroy its life. "To prevent their inhaling an animalcule, the more rigid of them wear a thin cloth over their mouths." The pinjaropol, or hospital for decayed animals, maintained in the city of Surat, finds amongst them enthusiastic supporters. But though they consider themselves on this account far superior to Christians in a moral point of view, the life of man is no more respected amongst them than it is amongst people who do not evince such exaggerated tenderness for the brute creation. We cannot refrain from quoting a short and significant discussion between a Jain priest and an English missionary:—

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* In proof that the habit of destroying animals of one particular species does not render a man generally indifferent to animal suffering, we may mention a case for which we can vouch:—A butcher discovered that a hen in his possession had contracted the habit of eating her own eggs. According to the laws of the poultry yard this offence is capital; but the butcher experienced a reluctance to kill the bird which he could not overcome, and he was obliged to send for a poulterer to perform the execution.

"You take life," said the Jain; "we take none."

"Oh! what a happy country yours must be," replied the missionary: "you have no wars——"

"We have wars," said the Jain, interrupting.

"I thought you said that your people never took life?" returned the missionary.

"We take only human life," said the Jain.

In fact, India has, generally speaking, shown that an overstrained tenderness for animals may coexist with great cruelty to man.* Southern Europe, on the contrary, has been consistently merciless to both man and beast, and has tortured heretics, Moors, Jews, bulls, and horses with the utmost impartiality. We see, therefore, that the utmost tenderness to brutes may be accompanied with cruelty towards men, just as, conversely, a habit of inflicting pain upon animals for certain purposes and on especial occasions may coexist with kindness to man, and even to the lower animals where such purposes are not involved. All this may, no doubt, be grossly inconsistent conduct, but inconsistency is one of the most cherished privileges of human nature, and anti-vivisectionists should be the last to complain of it. The real germ of cruelty, of which we all ought to beware, is the infliction of pain for frivolous, unworthy, or impossible ends, and especially the making it a source of gratification. From all this there is no one more remote than is the vivisectionist.

The agitators urge that vivisection is not a trustworthy method of interrogating nature. This objection, if well founded, would be decisive, since in that case all operations undertaken upon living animals would be mere gratuitous inflictions of pain, and would then be justly branded as cruelty; but, being unfounded, it is remarkable chiefly for its impudence. Might we not, in common charity, suppose that the distinguished physiologists of the past and the present who have from time to time undertaken experiments upon living creatures would be able to judge whether this method was safe or fallacious? Do they really require to be instructed on this head by unscientific outsiders? Can we really assume that physiologists would for one moment have recourse to a means so disagreeable if they could either discover a substitute, or if, on checking and verifying their results, they found them essentially delusive? The process is difficult, but so is all experimental enquiry; and few methods in any science have, in judicious hands, yielded a more splendid harvest. A medical contemporary justly remarks that "the whole history of medicine is pregnant with examples of benefits to humanity derived from such experiments."

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* The Turks are famed for their humanity to animals. What other nation, for instance, would not long ago have made a clean sweep of the loathsome dogs which infest the streets of Constantinople and of other large cities of the Ottoman Empire? Yet to man they have been merciless.

The discoveries of the action of the lacteal and lymphatic system, and of the compound function of the spinal nerves may serve as illustrations. These discoveries, it has been justly said, lie at the very foundation of our present knowledge of the laws of animal life. Yet these discoveries are mainly due to vivisection. Turning from abstract biology to practical medicine, what would be our treatment of the diseases of the heart and blood-vessels if we suppose Harvey's great discovery blotted out? Hunter's treatment of aneurism—a disease previously always fatal—springs from the same root, and was discovered and verified in the same manner. Look at the operation of ovariotomy, by which one single surgeon has saved the lives of more than five hundred women. This process, or at least a certain point which it involves, was first proved upon dogs, rabbits, and guinea-pigs. Without such preliminary experimentation no medical man would have ventured on a procedure formerly held necessarily fatal. To declare, then, that vivisection, as a means of research, is barren and deceptive, betrays an amount of ignorance which is positively indecent. It is the bounden duty of all who undertake to enlighten the public on any subject to make themselves first accurately and fully acquainted with all its bearings. Otherwise, instead of enlightening, they deceive and lay themselves open to the natural suspicion that such is their intention. He who comes forward in a court of justice to give evidence on matters which he does not know is considered a perjurer. Is not the position of the humanitarian zealot who scatters baseless assertions broadcast morally, though not legally, exactly similar? Surely the few illustrations which we have cited, capable as they are of being indefinitely multiplied, form an overwhelming proof of the value of vivisection, and must utterly silence all the cavils raised against it on the score of inutility. Nay, they ought, in our opinion, at least to be held decisive of the whole question. What, in opposition to such solid facts, are the hysterical utterances of Mænads who proclaim that their "hearts," and possibly other vital organs, are sick? Let no one say that we are advising to do evil that good may come; that which yields such essential services to the whole human race cannot be declared evil by any one, except he denies to man any rights over the brute creation whatsoever. The Royal Commissioners point out that most important researches, involving experimentation upon animal life, are now in progress. These relate to some of the "severest scourges which afflict the human race," such as cholera, consumption, blood-poisoning, typhoid, the bites of poisonous serpents. Are such investigations to be suspended? Were we prone to sensationalism, we might paint the shades of the thousands of our fellow-subjects who yearly perish in India from the bite of the thanatophidia hovering over the couch of the anti-vivisectionist fanatic, and shrieking in his ear that they might have been saved had he not begrudged the death of a few rabbits and guinea-pigs. No one can abhor more than do we the infliction of any wanton torment upon animals. We even object to all avoidable destruction of vegetable life. But if a remedy for the bite of the cobra alone could be found, we should consider it cheap if all the guinea-pigs in creation had been used up over the discovery.

There are those who declare that, rather than owe their life, or that of their children, to methods elaborated in such a manner, they are willing to die. It may be so, and we do not dispute their right to decide thus for themselves; but we entirely deny their right to speak for others. When they attempt this, when they seek to suppress vivisection, they fight—as humanitarians are very apt to do—not for liberty, but for supremacy. They seek to deprive others, who are not willing to die so long as a remedy can be found, of a source of benefit and safety.

But the boast of rejecting improved medical treatment founded upon the results of vivisection is idle and empty. They cannot, if they were to make the attempt. It is scarcely too much to say that whenever they consult a medical practitioner they enjoy more or less, and directly or indirectly, the benefits of discoveries made in this denounced manner. Can they efface from the mind of their physician or surgeon his knowledge of the circulation of the blood and all its consequences? Can they call up from their graves the ante- and anti-Harveians to treat their diseases? Surely, then, they are in a false position. They quench their thirst at a stream, and yet would seal up its springs!

We have now to ask, What is it that the anti-vivisectionists want, and what concessions would induce them to drop the subject and return to pursuits for which they are less glaringly unqualified? Here we must confess that, like all agitators, political or social, they enjoy a great and unfair advantage. With a Government, or a municipal body, or an incorporated company, it is at least possible to negociate, because there is in such cases some responsible head whose actions and words bind the body which he represents. But who is to bind an agitation like this? Suppose some of its most prominent representatives give to-day a formal statement of their views and of their requirements, to-morrow the whole transaction may be repudiated by a number of their coadjutors. The Society for the Prevention of Cruelty to Animals has, indeed, we suppose, an organisation and certain responsible officials, but can it bind all its members? Nay, have we not reason to suppose that every concession will be regarded as a mere instalment, to be immediately followed by fresh demands until total abolition is accomplished? This, and this only, and not regulation or Governmental inspection, is the real object held in view, and therefore we protest against the slightest concession. Before going in detail into some of the modest demands made upon the Legislature, we may consider what the term "Vivisection" is, in humanitarian circles, meant to cover. We shall be greatly mistaken if we confine the word to its strict grammatical sense. It is used where, accurately speaking, there is no "section" at all. Thus experiments upon animals to discover remedies for poisons or for diseases, or to test the action of some newly-discovered drug or chemical would be as decidedly inhibited as the cutting of a nerve or the irritation of some particular portion of the brain. Nay, it even appears that to place any animal under abnormal circumstances in order to observe the result would be criminal. For instance, the present writer has been engaged with experiments on the action of different colours of light, different temperatures and kinds of diet upon the development of certain insects. Should the anti-vivisectionists gain the day, he will have to discontinue his experiments under the prospect of imprisonment. Thus, in fact, physiological experimentation, as far as animals are concerned, will be at an end. Now let us look to the demands of the enemies of science, for as such they must be manifestly regarded. One proposal was "to render unlawful any experiment made for the mere (!) advancement of science." They could scarcely have given a more signal proof of their ignorance, and of their consequent unfitness and want of right to interfere with the subject. Nearly three centuries have elapsed since Francis Bacon uttered the memorable truth that one scientific principle, rightly established, draws after it "whole squadrons of practical applications." During these three centuries his saying has been illustrated and verified, in every branch of science, times without end, and might, we hope, have penetrated even to the "persons of consideration" who are raising the present hubbub, and yet we find them babbling about the "*mere* advancement of science," as if too frivolous a matter for consideration! The Royal Commissioners gravely reject this absurd proposal. They remind its sapient originators that the onward steps which have immortalised Harvey and Galvani were, when first made, "mere scientific discoveries," and that "the germ of a great discovery is often so small as to be scarcely perceptible, and yet it may contain in it the grandest results." All this is, of course, true; but it is somewhat sad when the education of "persons of consideration" is so far in arrears that they require to be reminded of such elementary truths. Sadder still when persons so ignorant will come forward as teachers of the public, and seek to overbear the truth with sensational clamour.

Another proposal is not merely absurd, but disgusting. It was demanded that any person writing, publishing, or selling any book or journal containing an account of experiments made upon living animals, should, on complaint being laid, be summoned to appear before a police-magistrate or a court of petty sessions, and, failing to prove to the satisfaction of the Bench that the experiments described did not involve cruelty to animals, should be liable to fine and imprisonment, as well as to the forfeiture of the books. According to this suggestion, which is simply a standing disgrace to its authors, the English student would be debarred even from reading the results obtained by foreign authorities. The works of the most illustrious biologists and the Transactions of the most honoured Academies would be placed on a level with the literature of Wych Street. The shops of our medical publishers would be beset with "active and intelligent officers," whilst detectives and spies, amateur and professional, would "get themselves up" as medical students, and come asking for some volume of forbidden lore in order to entrap the unwary bookseller, while in the background lurked some Secretary prepared with every quirk and quibble the Law could furnish in support of the charge. Should this suggestion ever become Law, a long step will have been taken towards the re-introduction of the censorship.

Indeed it would be far less irksome for biological writers to submit their works to the preliminary judgment of a censor than to live in fear of being dragged up to prove their innocence of cruelty before an over-worked and not over-cultivated police-magistrate, a bench of Shallows—ignorant and careless of Science, or, in the worst case, before a jury of adulterating tradesmen. We are neither politicians nor lawyers, and the "Quarterly Journal of Science" is no political organ; still we feel free to point out that this proposed interference with the medical press, in throwing the burden of proof upon the accused, involves a departure from the ancient spirit of English law and an attack upon one of the safeguards of our personal freedom.

Another proposal, aiming at limitation rather than destruction, is, that only qualified medical men should be allowed to experiment upon animals. Now that biology is one of the sciences upon which the art of medicine reposes is quite true, just as astronomy is one of the bases of the art of navigation; but to restrict biological research to medical practitioners would be as absurd as to confine astronomical investigations to officers of the navy. Biology will be more and more cultivated by students not directly connected with the medical profession, and certainly not practising as physicians or surgeons.

Let us now examine what ground is taken by the Royal Commissioners who occupy an impartial position between Science and her enemies. Their concessions here will seem to the agitators too little, whilst to us they appear too great. As regards experiments for mere demonstration performed in medical schools* they consider such both necessary and permissible under the regulation which already exists,—that they be performed under the influence of some anæsthetic. It may be assumed that the good sense and feeling alike of professors and students will prevent such experiments from being needlessly multiplied. No one, for instance, in our day, would think it necessary to drop a mouse into a receiver of carbonic acid, or to exhaust it under the air-pump. Phenomena so superabundantly demonstrated may now, surely, be received on authority, without experimental evidence.

As regards research—by far the more important branch of the question—they accept the principles laid down by the Physiological Section of the British Association in 1871, to which they propose that legislative sanction should be given, thus imposing what they designate as the "reasonable superintendence of constituted authority." All persons engaging in experimental research are to be licensed and registered by the Home Secretary, under certain conditions, and to be subjected to the visits of an Inspector. With this conclusion a medical contemporary expresses itself satisfied, considering that there is no reason to fear lest the proposed legislation should "in any material way" hinder the progress of research or diminish existing facilities, hoping that, on the other hand, such measures would "calm the needless apprehension, and put an end to the odious misrepresentations which have been recently rife concerning this subject, and which have been in ignorance adopted by persons of consideration, who will probably in future take more pains to be correctly informed."

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* In no others?

In these anticipations we find ourselves unable to agree. We must remember that in England a large amount of scientific work has always been performed by persons holding no official position, graduates of no college, and—as Giordano Bruno says of himself—"academicians of no academy." These men are in the outset of their career necessarily unknown. Will they always be able to fulfil all the formalities necessary to obtain a license? The Home Secretary assuredly will not grant every application made as a mere matter of form, yet if he does not there will be a possibility that the progress of research may be checked in a "very material way." In such matters we should dread the interference of the British Government more than that of any other. An authoritative definition of vivisection, and a clear exposition of the conditions under which licences are granted, will or should be included in the Bill, and if these are satisfactory it will be perhaps the first time that the British legislature has dealt advantageously with a scientific subject.

The hope that such a regulatory Act will put an end to "odious misrepresentations," and induce "persons of consideration"* to seek correct information before entering upon a career of agitation, is amiable, perhaps child-like; but it will be doomed to disappointment. Since that Report was published the anti-vivisectionists have showed no symptoms of relaxing their endeavours, or of desisting from the dissemination of "odious misrepresentations."

* Can any person, of whatever rank, be considered "of consideration" when speaking upon a subject of which he is utterly ignorant, and on which he has not even sought for "correct information"?

On the contrary, a book has appeared in which the Royal Commissioners are accused of having suppressed important evidence! We have even heard it rumoured that attacks are being made through private channels upon men known or supposed to be engaged in biological experiments. If they are medical practitioners, their patients are to be cautioned against placing themselves in such dangerous and cruel hands. In whatever sphere of life they move they are to be cut off, as far as possible, from the good offices of society. It may be said that those who employ weapons thus obviously borrowed from the trades'-unionists lay themselves open to legal proceedings; but it is not very easy for a private man of perhaps limited resources thus to contend with the creatures of a wealthy combination. We cannot, indeed, lay our finger upon any of the agents who carry on this game, nor can we prove that this or the other "person of consideration" is cognisant of what is taking place. It is sometimes convenient to be able, with technical truth, to deny all knowledge of dishonourable actions. To whatever extent these attacks may be carried, we submit that the anti-vivisectionists have proved themselves to be *intransigentes*. It is imprudent to make concessions to those whom no concession will satisfy.

There is still another reason why the Report of the Royal Commissioners should not be accepted. It is exceedingly bad policy to yield anything to agitators who have not made themselves acquainted with the facts of the case before disturbing the public peace and making unwarrantable and calumnious attacks upon private character. We think that all medical practitioners and all men of science are bound, in duty to themselves and the public, to oppose a firm and unbroken front to this senseless agitation.

We regret to find that Government has not merely decided to legislate on the subject of vivisection, but that the proposed measure will be more dangerous to science than we had any reason to fear. It is declared that—"A person shall not perform on a living animal any experiment calculated to give pain, except subject to the restrictions imposed by this Act." Here we come to the first difficulty. Who is to decide what experiments are or are not calculated to give pain,—a man of science or a humanitarian? If the latter, the wording of the clause might as well have been "any experiment whatsoever."

Again, not merely are the permitted experiments to be restricted to "registered places," and to be performed by "a person holding a license," but it is declared that "the experiment must be performed *only* with a view to the advancement by new discovery of knowledge which will be useful for saving or prolonging human life or alleviating human suffering." Thus the point against which the Royal Commissioners wisely made a stand is conceded, and experiments for the advance of general biological knowledge—except bearing directly upon the treatment of disease—are evidently proscribed. Vivisection is to be simply medical in its object. That this most objectionable clause is to be strictly interpreted appears from a subsequent proviso:—"Experiments may be performed not directly for the advancement by new discovery of knowledge which will be useful for saving or prolonging human life or alleviating human suffering, but for the purpose of testing a particular former discovery alleged to have been made for the advancement of such knowledge as last aforesaid, on such certificate being given as is in this Act mentioned that such testing is absolutely necessary for the effectual advancement of such knowledge."

Hence it would appear that the licensed experimentalist is not at liberty to perform such operations as may to him seem calculated for the advancement of science, but that he may be called upon, in any individual case, to explain his exact object and mode of procedure, probably to an Inspector under the Act, who may use his own judgment as to whether the researches proposed are permissible. Experiments undertaken with a view to the prevention or cure of disease in domestic animals—surely an important object—will, as far as we can judge, be considered illegal. The scale of penalties proposed is exorbitantly high,—a point of the greater importance if we remember that experimentalists will be subjected to organised espionage, and that, if once they are accused of "cruelty," swearing of the stoutest quality will be employed to secure their conviction. We can only repeat our regret that one of the most important sciences should be placed in a position so humiliating.

We have heard of the "endowment of research" as a something vaguely looming in the distance. It is becoming tangible at last in the shape of penalties of fifty and one hundred pounds, supplemented with months of imprisonment! Instead of King Log we have now King Stork; active persecution instead of contemptuous neglect. There has been much said lately about a great scientific revival in England. Should this Bill and the Patent Law Amendment Bill pass into law the present administration will have given that revival a blow which no empty courtesies can heal, and which will prove that whatever party is in power we have still "a Government very hostile to Science and to her disciples."* We may well exclaim, to Whig and Tory alike —"A plague on both your houses!"

IV. INFUSORIAL EARTH AND ITS USES.

BY DR. W. H. WAHL.

GEOLOGISTS have long since established, beyond peradventure, the fact that there are rocks in the interior of continents, at various depths in the earth, and at great heights above the sea, which are almost entirely made up of the remains of what were once living organisms. Such rock-masses, says Lyell, may be compared with modern oyster-beds and coral-reefs, and, like them, their rate of increase must have been extremely gradual. But there are a variety of mineral deposits that are now proved to have been derived from plants and animals, of which the organic origin was not suspected even by naturalists. Great surprise was therefore manifested when Prof. Ehrenberg, of Berlin, announced the discovery that a certain kind of siliceous stone, called tripoli, was entirely composed of the remains of countless millions of extremely minute organic beings. This observation of the famous German microscopist speedily led to the discovery of the fact that deposits of this character were quite abundant, and that they were even being formed at the present time over extended areas. The minute organisms, whose skeletons make up the bulk of the deposits which are now known under the name of infusorial earth, have been shown to inhabit the ocean in inconceivable numbers, giving rise to the luminosity of the waters, which has been the subject of much discussion, and flourishing in almost every place where water stands for several months of the year. Their indestructible shells are therefore to be found in greater or less quantity in the sedimentary deposits of all our bogs, ponds, and slow streams. They are found in great abundance beneath peat-bogs, where they constitute strata, often many feet in thickness and of great extent, almost entirely composed of the siliceous carapaces of organic beings, so inconceivably minute that millions of their remains are found in a single inch. Ehrenberg estimates that about 18,000 cubic feet of these siliceous organisms accumulate annually in the harbour of Wismar, in the Baltic. He has furthermore demonstrated that they accumulate in the beds of American and other seas, lakes, and rivers.

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* Eine der Wissenschaft und ihren Jüngern sehr abhold gesinnte Regierung.

The deep sea soundings which have lately been conducted in various quarters of the world, and have attracted much popular interest, have shown, likewise, that the impalpable mud or ooze which is accumulating at great depth in the bed of the Atlantic and other oceans is made up almost entirely of the mineral skeletons of certain extremely minute organisms. Of these shells, some are calcareous, and appear to be identical with the organisms which abound in the chalk of Europe—the chalk, indeed, is largely made up of such organic remains—while others are siliceous. One of these deposits in the North Atlantic has been traced over a distance of thirteen hundred miles in breadth, and not less than six hundred miles in length.

In peat-bogs, swamps, and the like, both of modern and ancient origin, there are often found layers, at times many feet in thickness, and of considerable extent, of a white siliceous paste, which is found beneath the microscope to be made up wholly of the remains of these minute organisms. These deposits, with which this article is chiefly concerned, are designated by geologists with the name of infusorial earth. The substance of which they are composed has generally, when dry, the appearance and consistence of friable chalk, and the remains of which it is made up, and which were formerly referred to microscopic infusoria, are now generally held to be plants, called by naturalists *diatomaceæ*. The remains of these diatomaceæ are of pure silex, and their shapes as seen beneath the microscope are various, and form objects often of extreme beauty. These forms are very marked and constant in particular genera and species, of which many hundreds have been described and classified by Ehrenberg, Bailey, and others, and while many of the fossil forms are identical with living species, others are allied to them; and the so-called infusorial beds are sometimes of marine and sometimes of fresh water origin. The infusorial earth may readily be distinguished from the several calcareous and clayey deposits which it resembles in appearance by the fact that it does not effervesce in acids, and its ready solubility in solution of caustic soda or potash. It has long been well known in the arts as a powder for polishing stones and metals. At Bilin, in Bohemia, which is famous for its occurrence, there is a single stratum of this material, not less in some places than 18 feet in thickness, and extending over a large area. This stone, when seen beneath the microscope, is found to consist of the siliceous plates or frustules of the above-mentioned diatomaceæ, united together without visible cement, and so inconceivably minute are the particles of which it is composed that, according to Ehrenberg's statement, a single cubic inch, which weighs about 220 grains, contains about 41,000,000,000 of individuals, and a single grain no less than 187,000,000. Other deposits of infusorial earth (kieselguhr), scarcely less extensive, occur in Germany, at Berlin, and at Planitz, in Saxony. It is found near Lüneburg, in a stratum nearly 28 feet in thickness, and again at Kliecken, near Dessau, and in the vicinity of Cassel. In England, deposits of considerable magnitude have been found in Surrey, at the base of the chalk hills, and elsewhere. In Ireland there is a celebrated stratum on the banks of the River Bann, in the county of Down, and which, from being in much request for polishing plate, is locally known as Lord Roden's plate powder; another bed is found at the base of the Mourne Mountains in the same county. In Lapland a similar earth is met with, which in times of scarcity, it is said, is mixed by the inhabitants with the ground bark of trees and used for food. The edible earth of Lillhaggsjon, in Sweden, is of the same nature. The infusorial earth is found in quantity in the Isle of France and at San Fiora, in Tuscany, and deposits of various thicknesses have been detected in Africa (the tripoli of commerce is an infusorial earth that has long been exported from the country whose name it bears), Asia, Australia, and New Zealand. In America it has been found in a great number of localities, and occasionally in enormous quantities. Of this nature are the beds of white earth along the banks of the Amazon, in Brazil, and used occasionally as food (?) by the native inhabitants. They have been detected also in Newfoundland and Labrador. In the United States perhaps the most remarkable deposit is that upon which the City of Richmond, Va., is built; this deposit is, in places, over 20 feet in thickness, and has been traced by Prof. W. B. Rogers, who was the first to point out its nature, from Herring's Bay on the Chesapeake, Md., to Petersburg, Va., and beyond. At Petersburg the stratum is 30 feet in thickness. Beds of the same character and of some magnitude have likewise been found in California, Oregon, and other points on the Pacific, and at West Point, N.Y.; while of less importance are the infusorial beds at

Wrentham and Andover, Mass., Smithfield, R.I., Stratford, Conn., and other localities too numerous to mention.

An interesting occurrence of this nature is the deposit of infusorial earth at Drakeville, Morris County, New Jersey, and which, through the instrumentality of the writer and others, was first brought into general public notice about three years ago. The bed in question is on the property of the late Frederick S. Cook, and is located at the foot of Schooley's Mountain. The annual report of Prof. George H. Cook, State Geologist of New Jersey for 1874, contained a descriptive article in reference thereto, from which we obtain the following statements concerning its probable extent, &c.

"It has been known as a white earth or marl for a long time, and some years since was dug out and spread upon the soil as a manure; it had also been observed to possess remarkable excellence for scouring silver. The establishment of a manufactory for making nitro-glycerine and giant powder at McCainsville, near Drakeville, in which infusorial earth imported from Germany was used, led to an examination of this deposit, when it was found to be the same material with that they were bringing from Europe. The deposit occurs in a depression of the surface just at the foot of the mountain (Schooley's). The swale appears to be occupied in its lowest part by a common swamp of low bushes, growing in wet black earth; but by digging in the black earth it is found to be only about a foot thick, and underneath it is the infusorial earth. The extent of the black ground is about 540 feet in length by 200 feet in breadth, and 100 yards north-east is another but much smaller deposit. A trial pit sunk in the middle of the swale showed a thickness of 12 inches of black earth, 8 inches of very light infusorial earth, and 12 inches or more of a much denser infusorial earth. The lower part is said to be 3 feet thick, but I only examined the upper foot of it."

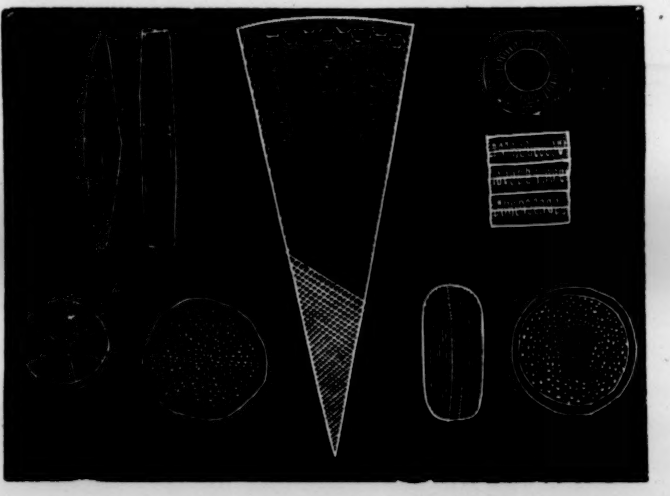
The report continues:—"There is little doubt that other deposits will be found in the small ponds and swamps in this gneiss region, and those interested will do well to make search for it in any of the swales where these little swamps occur. It can be easily reached by digging, and when found can be distinguished from any other white earth by its not effervescing with acids as white marl does, by its not becoming plastic when wet, as white clay does, and by its dissolving almost entirely in a strong boiling hot solution of washing soda.

"The importance of this material will be appreciated when it is stated that the manufacture of *dynamite*, or giant powder, at Drakeville, has reached £50,000 a month. There are different grades of *dynamite*, but some of it contains 25 per cent of infusorial earth."

An analysis of an average dried sample of the Drakeville deposit yielded the writer 47·12 per cent of soluble silica.

Concerning the application of this curious substance in the useful arts quite a chapter might be written. During the past few years it has attracted the special attention of practical men, and so many and various have been the uses for which it has been suggested that their bare enumeration may well excite surprise. At least one very important industry of recent origin has been practically created by it, and its employment in others is steadily growing in extent and importance. A summary of the subject in its technical aspects, with brief comments upon the more important items, is given in what follows.

The most popularly known and perhaps the earliest application of the diatomaceous earth is its utilisation as a polishing agent for stone and metals. For this purpose, when carefully freed from grit and other impurities, its considerable hardness and its wonderfully fine state of division fit it most admirably. It may be applied wet or dry. It is well known in this connection under the name of tripoli, so called from the locality whence it was originally brought. Under the name of "electro-silicon," "magic-brilliant," and other trade designations, the diatomaceous earth from Nevada and other localities has been extensively introduced as a polish for gold, silver, and plated ware, for which—as for tin, Britannia ware, and other metals used in the household—its wide popularity is the best proof of its excellence.



Being a very poor conductor of heat, it has been suggested and applied for surrounding ice, beer and ale cellars, fire-proof safes, steam-boilers, powder-magazines, refrigerators, &c. The results of certain experiments lately made by Refardt and Co., of Braunschweig, to ascertain how this material compared with other substances generally employed for the purpose, are highly favourable to the merits of infusorial earth for this application.

Without entering into the mechanical details of the apparatus employed in these trials, it will suffice to state that in the time required to melt 100 parts (by weight) of ice surrounded by the siliceous earth, 235 parts of ice were melted in a cylinder surrounded with an equally thick layer of dry, light garden earth. Moist earth, and moist materials generally, gave still more unfavourable results. Again, for every 100 parts of ice melted when protected by the infusorial earth, 142 parts of ice protected by dry, sifted coal ashes, were melted. The results obtained with flax-shives were about the same as with the infusorial earth. These trials demonstrated that infusorial silica and flax-shives offer the greatest amount of resistance to the transmission of heat; that dry coal-ashes are far less efficient, and moist ashes still more so; and finally that earth, as compared with these, is very inferior as a non-conductor. The use of the infusorial earth is therefore highly recommended for filling in between the walls, and for covering the mason work in ice-cellars. For this purpose the following additional advantages are urged in favour of this substance, viz.:—It is extremely light,—being nearly five times as light as dry earth, and about half the weight of dry coal ashes,—and it is not combustible, remaining unaffected in the hottest fire. These properties, to quote from the published account of the above trials, render this substance preferable to flax-shives, tanbark, peat, saw-dust, and similar materials, which are about equal to it in non-conducting quality, but which are combustible, and when kept for some time rot or moulder, shrink and settle, and might under some circumstances, take fire spontaneously (*sic!*).

The infusorial earth, it is further claimed, will be found highly useful in fire-proof safes, as a surrounding for powder-magazines on shipboard, for covering steam-pipes and boilers, and for all similar purposes. Reference is made in some of the encyclopædias (*vide* "American Encyclopædia," iii., 268) to what are termed floating bricks, which, according to account, are made of infusorial earth, and are named in virtue of their power of floating upon water. Clay is sometimes added to the silica to assist in binding the material together. Such bricks, we are told, were made in ancient times, and were described by Posidonius and Strabo, and particularly commended by Vitruvius, Pollio, and Pliny. In 1791 they were again brought into notice by Giovanni Fabroni, in Tuscany, who, after many trials, succeeded in making bricks which would float upon water. Their strength was but little inferior to that of ordinary bricks; they are remarkable not only for extreme lightness, but also for their infusibility, and for being very poor conductors of heat; they may be held at one end while the other is red-hot. As an experiment, Fabroni constructed the powder-magazine of a wooden ship with these bricks; the vessel being set on fire, sank without explosion of the powder. In 1832 Count de Nantes, and Fournet, a mining engineer, used them in constructing powder-magazines and other parts of ships, thus lessening danger from fire. From an earlier source ("Encyclopædia Americana," ii., 266) we are informed that these floating bricks, made of agaric mineral or fossil farina, —infusorial earth,—has been found, on account of its infusibility at the highest temperatures, to be extremely useful in constructing reverberatory furnaces, pyrometers, and magazines of combustible materials, while their lightness and non-conducting qualities render them particularly useful for the construction of powder-magazines on board of ships.

In agriculture, the use of the infusorial earth has been suggested as a manure for lands poor in silica, which substance enters importantly into the constitution of the stalks and outer coverings of cereals. Quite an animated controversy, indeed, has of late sprung up as to the merits of infusorial silica as a component of fertilisers, an idea which forms the essential feature of a patent lately issued to Messrs. N. and G. Popplein, Jun., of Baltimore. It would be foreign to the purpose of this sketch to enter into a discussion of the merits of this controversy, involving as it does the introduction of certain debatable questions in agricultural chemistry; but the ideas of the Messrs. Popplein have aroused on the one hand such warm championship, and on the other such opposition, that a concise statement of the points in dispute may not be amiss.

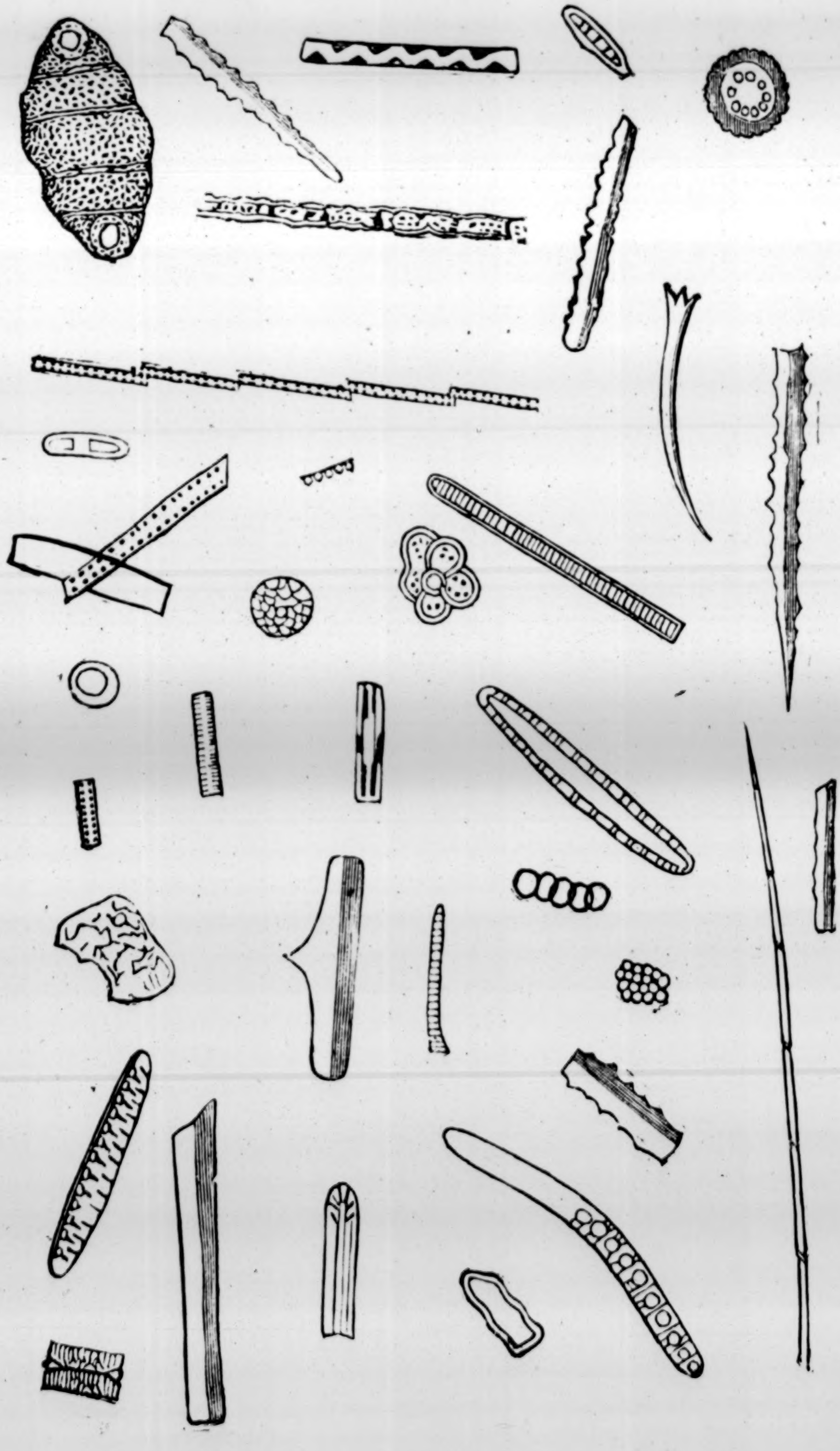
The manufacturers before named, proceeding from the well-known fact that the relative quantity of silica in the ash of the cereals is greatly in excess of what is required for the normal combination with the bases (potash, soda, &c.) found therein, claim that in the ordinary course of things it is impossible for Nature to furnish to cultivated lands for successive years the proper amount of silica in assimilable form for the plant, inasmuch as the liberation of this substance by the chemical decomposition of the mineral matters of the soil containing it, goes on so slowly as to render doubtful the production in many years of the amount required for a single crop. In proof of this assertion they refer to the great reduction in the yield of the wheat crop, since farmers began years ago to sell the straw of the crop that formerly was returned to the soil. For this, and other reasons less obvious, their attention was attracted to the importance of incorporating silica into commercial fertilisers —one difficulty remained to be overcome, namely, the discovery of a form of the silica—which should be assimilable by the plant. This they claim to have found in the infusorial earth,—in which the silica is in an inconceivably minute state of division,—the result of their consideration being the production of a so-called "silicated superphosphate of lime," a superphosphate with which the infusorial earth is intimately incorporated. The argument urging the importance of an abundant supply of silicic acid in available form, as an absolute necessity for the proper nutrition of cereals, is not disputed; and the manufacturers, to demonstrate the availability of the silica in the form in which they employ it, have actually succeeded in proving beyond question the highly interesting and novel fact that the very minute skeletons or shells of which the infusorial earth is mainly composed are carried up *as such* into the body of the plant itself. Upon this point the following gleanings from an investigation conducted by Prof. P. B. Wilson will be read with interest:—

This chemist subjected to a microscopical examination the straw from the wheat-fields of Col. J. B. Kunkel, of Frederick County, Maryland, which had been fertilised by the silicated phosphate, his purpose being to make "a more complete investigation into the siliceous structure of the stalk, in determining whether the Infusoria passed directly as such into the sap-cells, to be carried forward by capillary force, and to finally assume their functions,—the formation of the epidermal shield for giving strength to the straw, to withstand the destructive force of high winds and beating rains, as well as a protection against the attacks of parasites."

"In making these investigations thorough precautions were observed, to cleanse the straw from all accidental impurities by washing and gentle friction, not sufficient, however, to destroy the epidermis. The organic matter was

Forms of Diatoms found in Col. Kunkel's Straw.

MAGNIFIED 300 DIAMETERS.



then removed by the prescribed methods, aided by my own experience."

"My labours," he continues, "have been amply rewarded by one of the most enchanting views that has ever fallen to my lot to behold through twenty years of varied scientific investigations. When the epidermal siliceous coating was adjusted upon the field of the microscope, some thirty-six forms of the Diatomaceæ, which I have carefully sketched, were observed (see engraving, magnified 300 diameters) where perfect disintegration has been produced. When the structure to a great extent is retained a marvellous interlacing of these forms presents itself, sometimes side by side, at other times overlapping."

From this very interesting observation, Prof. Wilson advances a number of inferences, which, although the writer is not prepared to accept in full, are of sufficient interest to warrant their reproduction. He affirms that his investigation "overthrows all theories that have ever been advanced, that silica enters into plant structure in combination with the alkalies, the alkaline earths, or the earths proper. Chemical investigation led me to this conclusion some months since, now confirmed by that of the microscope."

"My mind was particularly impressed with the absence of the disc-like form, the *Actinocyclus ehrenbergii* and the *Actinoptychus undulatus* in their perfect state in the straw, while the other forms are common both to the infusorial earth and the wheat. My conclusions are that the varieties mentioned are too large to enter the root capillaries, for on the field of the microscope they have three to four times the magnitude of the others. This I will fully investigate during the coming summer, by making accurate measurements of rootlets and diatoms, when I will be able to obtain stalks of wheat as grown in the fields, preferring this mode of investigation to *pot culture*, to disarm controversy, and to divest the investigation of all semblance of laboratory experiment."

"I have examined various specimens of wheat straw taken at random from the market, but have failed to find a single diatom. This to a certain extent surprised me, when taking into consideration that they are found to a limited extent in Peruvian guano. The inference to be drawn is, that the soil was not fertilised by any material into which it entered as a constituent. I mention this to guide others who may make subsequent investigations from falling into error, in case occasional Diatomaceæ are observed, as being derived from other sources than the infusorial deposits."

"These microscopic investigations show the absence of other forms of silica, that is, in granular particles in the (Kunkel) straw, they being entirely replaced by diatoms. This leads to the conclusion that the diatom is the more acceptable for assimilation, and when sufficient infusorial remains are present, replaces any other divided form of silica. I have previously attempted to substitute silica for diatoms, as obtained from the decomposition of slags from iron furnaces, but have failed to derive any satisfactory results. This is due to its combination as a silicate; and when liberated by stronger acids, it agglutinates into masses too hard and large to be absorbed by the plant."

Prof. Wilson concludes his report in the following glowing terms:—"I look upon this application of vegetable silica to fertilising purposes as the most important adaptation of matter for the reproduction of vegetation that has ever been discovered. It is the first step in a new direction, rationally conceived and judiciously carried out. A new impetus will be given to the study of plant physiology, which will demonstrate that more than a heterogeneous mixture of elementary bodies and their compounds are required for the production of the crops beneficial to the requirements of man."

With regard to the foregoing statements and inferences of Prof. Wilson, while not attempting to undervalue their great interest and possible entire accuracy, the writer would remark that the demonstration of the presence of the infusorial forms in the structure of the wheat stalks proves simply that these bodies are sufficiently minute to enter the root capillaries and pass into the sap-cells of the plant—nothing more. It may possibly be that, once having entered the body of the plant, they are assimilated, and made to subserve to the function of giving strength to the stalk; or, as appears to the writer equally plausible, they may simply act as so many minute mechanical impurities drawn into the circulation of the plant, and, effecting a lodgment wherever they chance, clog up the passages, and thus actually obstruct rather than serve the process of nutrition. To follow the history of one of these forms in a living plant under the microscope, and observe its gradual dissolution, would afford the only method of positively proving the truth or falsity of either of the explanations that have been presented. While not presuming to decide so doubtful a question, it is very reasonable to believe that much of the silica of the so-called silicated superphosphate is made "available" as plant-food in solution as an alkaline salt, in which condition its assimilation by the plant presents no difficulties to the understanding. Dr. Wolf, the excellent

State Chemist of Delaware, has kindly furnished the writer the following record of an analysis of the "silicated superphosphate," viz.:—

Soluble Phosphoric Acid	5·855	per cent
Precipitated Phosphoric Acid	3·327	,,
Insoluble Phosphoric Acid	trace	
Silica	20·568	,,
Sulphate of Potassa	6·173	,,

According to the Messrs. Popplein's published formula, the net ton of their "silicated superphosphate" contains—

Infusorial Earth	800 lbs.
Dissolved Bone	800 ,,
Potash Salts	400 ,,

As an absorbent and carrier of liquids of various kinds, and especially as a carrier of nitro-glycerine, the infusorial earth has been found to be most excellently adapted. It takes up from three to five times its weight of water, oil, nitro-glycerine, &c. It would doubtless prove equally valuable as a carrier of carbolic acid and other disinfectants, as a disinfecting powder, and has possibly already found application for this purpose.

In order to bring nitro-glycerine within the range of articles of transport, Nobel, who first demonstrated its value in the arts, devised the production of the powder now so extensively employed under the name of dynamite, in which the explosive oil is simply carried by the inert, pulverulent siliceous earth. The process of the preparation of dynamite may be described as follows:—

The infusorial earth must first be freed from water, organic substances, and mechanical impurities (sand, &c.) The first two are removed by calcining at a red heat in an oven with several shelves, one above the other, on which the earth is placed and slowly pushed from the upper to the lower. The organic matter, which is considered dangerous to the stability of the dynamite, is thus burned out. It is then pressed with hard rollers and sifted, which separates it from the larger particles and grit. It is now ready for use.

Fifty pounds of infusorial earth are put into flat wooden tanks and covered with 150 pounds of nitro-glycerine, when the workmen mix them with the naked hand. Gloves of india-rubber were at first provided, but the workmen preferred to knead the mixture with the free hands. In half an hour the incorporation of the oil with the earth is complete, and the dynamite is ready for filling in the cartridge moulds. The cartridges are simple cylinders, protected by parchment paper. If ordinary paper is used the oil soaks into it, and there is great danger of premature explosion. Dynamite is a brownish grey, sometimes reddish, inodorous, pasty, greasy mass, having the specific gravity of 1·6. When ignited by an ordinary flame, it burns up quickly without detonation, and must therefore be fired with a patent exploder containing fulminate of silver inclosed in a copper capsule. It requires a heavy blow of a hammer on an anvil to explode it, and even then only the portions struck are fired. In this respect it presents great advantages over nitro-glycerine, which is easily exploded by percussion. On the other hand, the wood of the boxes in which dynamite is packed becomes by slow degrees impregnated with nitro-glycerine, and forms a most dangerously explosive material, which may give rise to serious accidents in warehouses where it is stored. As long as the nitro-glycerine is confined in the infusorial silica there appears to be very little danger, but the escape of a few drops of the oil may be the source of great mischief. The force exerted by the dynamite is much greater than that of gunpowder, and under the name of giant powder it has been largely employed in the mines of California. Other explosives, such as dualine and lithofracteur, may be said to be varieties of dynamite, having nitro-glycerine for their base, and using saw-dust or some other substance as an absorbent. All of them are powerful explosives, and must be handled with care.

For the preparation of cements and of artificial stone a number of processes have been devised, in which infusorial earth plays a prominent part, viz.: Equal parts of infusorial silica and litharge, and one-half part of slaked lime, stirred to a paste in linseed oil, is affirmed to become as hard as sandstone on setting, and is recommended as an excellent compound for cementing stone, metal, and wood. The following recipe, again, is pronounced to be serviceable for the production of an artificial stone for art objects. For this purpose the infusorial earth is intimately mixed with well-pulverised, freshly-burned lime, in the proportion of from three to six parts of the former to one of the latter. The mixture is then pressed into moulds under an addition of a very slight quantity of water. The resulting product, a silicate of lime, is formed with the evolution of considerable heat. The objects produced ultimately attain great hardness; they are perfectly water-proof, and may readily be coloured with any colour used in stereochromy.

In combination with sulphur, infusorial earth forms a plastic mass, called zeiodelite; but no uses have yet been made of it.

By far the most important application of infusorial earth in this direction, however, has been successfully accomplished by Mr. Frederick Ransome, of England, in the production on the large scale of an artificial stone for general purposes, to which he has given the name of apoenite. The so-called "Ransome stone," invented by this gentleman, is made by thoroughly incorporating sand and silicate of soda in a mixing mill, moulding into the form required of the block, and then saturating the same with a solution of chloride of calcium, either by exhausting the air with air-pumps, or by forcing the solution through the moulded mass by gravitation or otherwise. The result is the formation of an insoluble silicate of lime, which firmly cements the particles of which the mass is composed, and of chloride of sodium or common salt, which is subsequently removed by the free application of water. The process of washing to remove all traces of the salt from the Ransome stone, which is necessary to prevent its efflorescence and secure its proper cementation, was found to be in many cases so tedious, expensive, and objectionable that the inventor, after many experiments, devised the following process, in which the use of chloride of calcium is avoided. Mr. Ransome mixes suitable quantities of lime (or substances containing lime) and soluble silica (*i.e.*, infusorial earth) with sand, and a solution of silicate of soda or potassa, which, when intimately incorporated, are moulded as before, and allowed to harden gradually, as the silicate of lime, produced by the action of the lime on the silicate of soda, is formed. As rapidly as the soda (or potash) of the water-glass solution is set free, it dissolves some of the infusorial silica, and again gives it up to the lime to form more cement, acting thus as the carrier of silica to the lime, until eventually all the lime is combined. In the course of the successive changes that take place, a portion of the free alkali appears to be bound at each step, with the lime as a compound silicate; and as the result of these several changes the whole of the alkali is gradually fixed, thus leaving nothing to be washed out. The mass gradually becomes thoroughly indurated, and in a very short time is converted into a very compact stone—apoenite—capable of withstanding enormous pressure, and increasing in strength and hardness with age.

In combination with magnesite (carbonate of magnesia), infusorial earth forms what is described as an excellent cement, which is manufactured in Germany, and sold under the name of "albolite."

In pottery the infusorial earth has received several important applications. When fused, for example, with borate of lime, as such is obtainable in the trade under the name of boronatrocalcite or tincalzite, an excellent glazing is produced ("Manufacturer and Builder"), which is not only useful for furnaces and pottery of all kinds, but also for enamelling iron and slate, being free from lead and not apt to crack off. By fusing a mixture of infusorial earth (freed from sand) with borate of magnesia (stassfurtite), a kind of "hot-cast porcelain" is produced, having great durability and beauty. For this purpose the infusorial earth requires to be perfectly dry and free from lumps. It is introduced into the crucible in small portions and under constant stirring, until the fused stassfurtite ceases to take up more. The mass may be cast like glass, and if very liquid it may even be blown, and is thus fitted for an extensive application (*ibid.*).

Bœttger publishes the observation that when an alcoholic solution of any of the coal-tar colours is mixed with a sufficient quantity of infusorial earth, water added, and the mixture filtered, the liquid will run off clear, while the earth retains all the pigment. Hitherto the compounds of alumina have been used for the production of the so-called lakes, and it is quite probable that the above-noted behaviour of this material may find important applications in the arts.

The use of infusorial earth has been suggested in glass-making as a substitute for sand; but it appears not to be well suited for this purpose, the reason assigned being that it swells too much in the crucible. In the manufacture of soluble glass (water-glass), for which it has likewise been tried, the impurities it contains—clay, phosphate of lime, &c.—have been found to render it somewhat unsuitable.

To conclude a sketch which has unwittingly taken considerable proportions, the following enumeration will suffice to show that the subject is by no means exhausted: —A compound called diatite, devised by Merrick, consists of gum-lac and infusorial earth. The siliceous earth has been added to sealing-wax to prevent its running; it is sometimes added to paper to give it body; and to soap for the same purpose, and to add to its detergent qualities (?); and it is said to form an excellent addition to rubber, for certain uses of the latter; its addition to modelling clay is said to prevent it from cracking in moulding; and lastly, though doubtless many real or suggested applications of this curious substance have been overlooked, it is said to be of use in the manufacture of smalt and ultramarine.

V. THE NIZAM DIAMOND—THE DIAMOND IN INDIA.

By Captain Richard F. Burton.

IT is impossible to quit Golconda without a word concerning the precious stone which, in the seventeenth century, made its name a household word throughout Europe; and also without noticing the great diamond whose unauspicious name, Bala (little) Koh-i-núr, I would alter to "The Nizam." It is a singular fact that professional books,—like Mr. Lewis Dieulafait's "Diamonds and Precious Stones" (London: Blackie, 1874),—which give full particulars of all the historic stones, have utterly ignored one of the most remarkable.

The history of the Nizam diamond is simple enough:—About half a century ago it was accidentally found by a Hindu Sonár (goldsmith) at Narkola, a village about 20 miles east of Shamsábád, the latter lying some 14 miles south-west of the Lion City, Haydarábád, on the road to Maktal. It had been buried in an earthen pipkin (Kotí or Abkhorah), which suggests that it may have been stolen and was being carried for sale to Mysore or Coorg. The finder placed it upon a stone, and struck it with another upon the apex of the pyramid. This violence broke it into three pieces, of which the largest represents about half. With the glass model in hand it is easy to restore the original octohedron. The discovery came to the ears of the celebrated Diwan (minister) Rajah Chandù Lál, a friend of General Fraser, who governed the country as Premier for the term of forty-two years. He very properly took it from the Sonár before it underwent further ill-treatment, and deposited it amongst his master's crown jewels.

The stone is said to be of the finest water. An outline of the model gives a maximum length of 1 inch 10·25 lines, and 1 inch 2 lines for the greatest breadth, with conformable thickness throughout. The face is slightly convex, and the cleavage plane produced by the fracture is nearly flat, with a curious slope or groove beginning at the apex. The general appearance is an imperfect oval, with only one projection which will require the saw: it will easily cut into a splendid brilliant, larger and more valuable than the present Koh-i-núr.

I can hardly wonder at this stone being ignored in England and in India, when little is known about it a Haydarábád. No one could tell me its weight in grains or carats. The highest authority in the land vaguely said "about 2 ounces or 300 carats."* The following statement has been made by Mr. Briggs:—"Almost all the finest jewels in India have been gradually collected at Haydarábád, and have fallen into the Nizam's possession, and are considered State property. *One uncut diamond alone of* 375 *carats is valued at* 30 *lakhs of rupees*, and has been mortgaged for half that money."

For uncut stones we square the weight (375 × 375 = 140,625) and multiply the product by £2, which gives a sum of £281,250. For cut stones the process is the same, only the multiplier is raised from £2 to £8. Thus, supposing a loss of 75 carats, which would reduce 375 to 300 (300 × 300 = 90,000); on multiplying the product by £8 we obtain a total value for the Nizam's diamond of £720,000.

I will now briefly compare the Nizam diamond—uncut 375 carats, cut 300—with the historic stones of the world. The list usually begins with the Pitt or Regent, the first cut in Europe. When the extraneous matter was removed, in unusual quantities, it was reduced to 136¾ carats, valued from £141,058 to £160,000. The Koh-i-núr originally gauged 900 carats; it was successively reduced to 279 or 280 (Tavernier), and to 186¼ (= £276,768) when exhibited in Hyde Park; its latest treatment left it at 162½ carats. Then we have the Grand Duke's, or Austrian, of 139½ carats (= £153,682); the Orloff, or Russian (rose cut), of 195 (193?) carats; and the Abaïte, poetically called the Star of the South, weighing 120 carats. The "Stone of the Great

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* Our diamond weights are as follows:—

16 parts = 1 (diamond) grain = 4-5ths grain troy.
4 diamond grains = 1 carat = 3-1-6 (3·174 grains troy).

The Indian weights are—

1 dhan = 15-32 grains troy; in round numbers ½ a grain.
4 dhary = 1 rati = 1⅔ grains troy.
8 rati = 1 masha = 18 grains troy.
12 mashas = 1 tola = 180 grains troy.

The "ounces" in the text probably represent "tolas," certainly not troy ounces of 24 grains.

Mogul," mentioned by Tavernier, is probably that now called Daryà-i-núr: it weighs 279 9-16 carats, and graces the treasury of the Shah. The nearest approach to "The Nizam" is the Mattan or Laudah diamond, of 376 carats. Experts agree to ignore the Maganza, whose 1680 carats are calculated to be worth £5,644,800: the stone is kept with so much mystery that it is suspected to be a white topaz.

Diamonds have been found in the Ganges Valley. They are still washed as far north as Sambalpúr and the Majnodi, an influent of the Mahanadi; on the Upper Narbada (Nerbudda), on the line of the Godaveri and on the course of the Krishna. The extreme points would range between Masulipatam and the Ganges Valley: the more limited area gives a depth from north to south of some 5° (=300 direct geographical miles), beginning north from the Central Provinces and south from the Western Ghats, a breadth averaging about the same extent, and a superficies of 90,000 miles. A considerable part of this vast space is almost unexplored.

The history of the diamond in India begins with the Mahabharata (B.C. 2100). The Koh-i-núr is supposed to have belonged to King Vikramaditya (B.C. 56) and to a succession of Moslem Princes (A.D. 1306) till it fell into the hands of the Christians. At what period India invented the cutting of the stone we are as yet unable to find out; the more civilised Greeks and Romans ignored, it is suspected, the steel wheel. The Indian diamond was first made famous in Europe by the French jeweller, Jean Baptiste Tavernier (born 1605, died 1689), who made six journeys to the Peninsula as a purchaser of what he calls the Iri (hira).

Tavernier's travels are especially interesting to diamond-diggers. He began with "Raulconda," in the Carnatic, some five days' journey south of Golconda, and eight or nine marches from Vizapore (*hodie* Bijapur). In 1665 the diggings were some two hundred years old, and they still employed 60,000 hands. The traveller's description of the sandy earth, full of rocks, and "covered with coppice wood, nearly similar to the environs of Fontainbleau," is applicable to the Nizam's country about Haydarábád. The diamond veins ranged from half an inch to an inch in thickness, and the gangue was hooked out with iron rods. Some of the stones were valued at 2000, and some even at 16,000 crowns; the steel wheel was used for cutting. Tavernier then passed on to the Ganee diggings, which the Persians call Coulour (*hod.* Burkalún), also belonging to the King of Golconda. These diggings lay upon the river separating the capital from Bijapur. The discovery began about A.D. 1565 with a peasant finding a stone gauging 25 carats. Here, we are told, appeared the Koh-i-núr (900 carats), which "Mirzimolas," or "Mirgimola," the "Captain of the Moguls," presented to the Emperor Auranzib. The 60,000 hands used to dig to the depth of 10, 12, or 14 feet, but as soon as they met with water there was no further hope of success. Tavernier's last visit was to "Soumelpore" (Sambalpur) "a town of Bengala, on the River Gowel," a northern affluent of the Mahanadi. The season for washing the diamantiferous land began in early February, when the water ran clear,—other authors make it extend from November to the rainy season,—and the 8000 hands extended their operations to 50 *kos* up stream. Gold, and the finest diamonds in India—locally called "brahmans"—were found in the river bed and at the mouth of the various feeders.

In 1688 and 1728 Captain Hamilton describes the diamond mines (probably those of Partial in the Northern Circars) as being distant a week's journey from Fort St. George, and records the fact that the Pitt diamond was there brought to light.

The diamond was practically limited to Hindostan and Borneo before A.D. 1728, when diggings were opened in the Brazils. The specific gravity of the diamond averages 3·6, and the difference of oxide in the crystallised or allotropic carbon does not exceed the third place of decimals. This, however, makes all the difference in lustre, for a small brilliant of perfect water is far more effective as an ornament than a larger stone of inferior quality. As far back as 1868 my study of the Brazilian diamond formation enabled me to prognosticate that the gem would be found in places where its existence had never been suspected. Since that time diamonds have been found in the Cudgegong River, near Rylston, New South Wales, and more recently in South Africa: these stones are inferior to those of the Brazils, yet they have reduced the value of the latter by one-third.

"The diamond mines of Golconda," according to Mr. Briggs, "derive their name from being in the kingdom of Golconda, and not from being near the fort. They are at the village of Purteeali (Partiál), near Condapilly, about 150 miles from Haydarábád, on the road to Masulipatam.*

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* Mr. Maclean kindly drew my attention to the Treaty with the Nizam (Nov. 12, 1766), which cedes to the East India Company "the five Circars or provinces of Ellour (Ellore, north of Masulipatam), Rajahmoudra Siccacole

The late Nizam retained possession of them when he ceded the Northern Circars to the English Government. They are superficial excavations not more than 10 or 12 feet deep in any part. For some years past the working of them has been discontinued, and there is no tradition of their having ever produced very valuable stones."

Mr. Briggs's report is full of errors. He must have known that the Pitt diamond—one of the finest and most perfect of its kind—was produced at Gáni Partiál, and that the Koh-i-núr came from the so-called "Golconda mines." Again, Partiál—on the north bank of the Krishna, some 50 miles from the Bay of Bengal—is only one of many diggings in the vast area which I have before indicated, some being still worked, and the others prematurely abandoned.

The student will do well to consult the "Geological Papers on Western India" (Bombay, 1857), edited by my old friend Dr. Henry J. Carter. Here he will find detailed notices of a number of mines. John Malcolmson, F.R.S., treats of the diggings at "Chinon on the Pennar" and the Cuddapah mines. Of the latter Capt. Newbold says—"The diamond is found in the gravel beds of the Cuddapah district below the Regur"—the black, tenacious, and fertile soils of Central and Southern India. The same scientific officer also describes the yield of Mullavelly (or Malavilly) north-west of Ellora, as occurring in a bed of gravel, composed chiefly of rolled pebbles of quartz, sandstone, chert, ferruginous jasper, conglomerate, sandstone and kankar, lying in a stratum of dark mould about a foot thick. Both these geologists inferred the identity of the sandstone of Central with that of Southern India from the existence of the diamond at Weiragad, a town about 80 miles south-east of the capital. Malcolmson declared that the "celebrated diamond mines of Partel (Partiál), Banaganpilly, and Panna, occurring in the great sandstone formations of Northern India, as well as the limestones and schists associated with them, exhibit the same characters from the latitude of Madras to the banks of the Ganges, and are broken up or

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(or Chicacole on the Coast), and Moortizanuggur or Gunton. The first four named were added to the French dominions by De Bussy. "These Circars," we read, "include territory extending along the coast from the mouths of the Kistna (Krishna) northward to near Ganjour, and stretching some distance inland." Article No. 11 of the same treaty runs thus:—"The Hon'ble E. I. Company, in consideration of the diamond mines, with the villages appertaining thereto, having been always dependent on H. H. the Nizam's Government, do hereby agree that the same shall remain in possession now also."

elevated by granite on trap rocks, in no respect differing in mineralogical characters or in geological relations."

The Rev. Messrs. S. Hislop and R. Hunter, who visited and described the Nagpur mines, object to this assertion, and endeavour to prove that the "diamond sandstone of the Southern Marathá country is a conglomerate reposing upon the arenaceous beds, which have *never* yielded the precious stone, nor are there any data to prove that the conglomerate derived most of its materials from that source." Dr. Heyne contributed an excellent description of the mines of Southern India, especially those of Banaganpilly, of Ovalumpilly (6 miles from Cuddapah), and of others on the Ellore district. This experienced geologist concludes that all these diamond mines can be considered as nothing else than alluvial soil." Major Franklin ("Geolog. Trans.," 2nd Series, vol. iii., Part 1), who visited the mines of Pannah in Bandelkhand, before Victor Jacquemont's day, makes the diamond sandstone between the Narbada (Nerbudda) and the Ganges belong to the "New Red," apparently an error; and others have described the diggings east of Nagpur (Central Provinces) as having been opened in a matrix of lateritic grit. Dr. Carter ("Summary of the Geology of India," pp. 686-91) connects the "diamond conglomerate" with the Oolitic series and its *débris*, and he gives a useful tabular view of the strata in the mines of Banaganpilly, described by Voysey, and Pannah or Punna by Franklin and Jacquemont. The most important conclusion is their invariable connection with sandstone.

Dr. Carter's volume quotes largely from the writings of Mr. Voysey (Journal As. Soc., Bengal; Second Report on the Government of Haydarábád), a geologist who maintained the growth of the diamond as others do of gold: he declared that he could prove, in alluvial soil, the re-crystallisation of amethysts, zeolites, and felspar. During his last journey from Nagpúr to Calcutta, he visited the diamond washings of "Sumbhulpore" in the Mahanadi Valley, and he describes the gems as being "sought for in the sand and gravel of the river, the latter consisting of pebbles of clay-slate, flinty slate, jasper, jaspery iron stone of all sizes, from an inch to a foot in diameter."

We possess, fortunately, a modern description of the Diggings which I have said were visited successively by Major Franklin and by Victor Jacquemont. M. Louis Rousselet ("L'Inde des Rajahs," Paris, Hachette, 1875), in his splendid volume, gives an illustration and an account of the world-famous mines of Pannah, the Pannasca of

Ptolemy (?), a little kingdom of eastern Bandelkhand, erected in 1809. The Rajah sent a jemadar to show him the Diggings, which are about twenty minutes' walk from the town. The site is a small plateau covered with pebble-heaps, and, at the foot of a rise somewhat higher than usual, yawns the pit about 12 or 15 feet in diameter by about 180 feet deep. It is pierced in alluvial grounds, divided into horizontal strata, *débris* of gneiss and carbonates, averaging 13 metres: at the bottom is the diamond-rock, a mixture of silex and quartz, in a gangue of red earth (clay ?). The naked miners descend by an inclined plane, and work knee-deep in water, which the Noria or Persian wheel turned by four bullocks is insufficient to drain; they heap the muddy mixture into small baskets, which are drawn up by ropes, whilst a few are carried by coolies. The dirt is placed upon stone slabs, and sheltered by a shed; the produce is carefully washed, and the siliceous residuum is transferred to a marble table for examination. The workmen, each with his overseer, examine the stones one by one, throwing back the refuse into a basket: it is a work of skill, as it must be done with a certain rapidity, and the rough diamond is not easily distinguished from the silex, quartz, jasper, hornstone, &c.

Tradition reports that the first diamonds of fabulous size were thus found, and the system of pits was perpetuated. When one pit is exhausted it is filled up, and another is opened. The system is bad, as 100 cubic metres must be displaced to examine one, and around each well a surface of twenty times the area is rendered useless. Moreover, much time is lost by the imperfect way of sinking the shaft, which sometimes does not strike the stone.

This diamond stratum extends more than 20 kiloms. to the north-east of Pannah; the most important diggings are those of the capital, of Myra, Etawa, Kamariya, Brijpur, and Baraghari. The mean annual produce ranges between £40,000 and £60,000—a trifling sum, considering that the stones are the most prized and sell for a high price. They are pure and full of fire; the colour varies from the purest white to black, with the intermediate shades, milky, rose, yellow, green, and brown. Some have been found weighing 20 carats, and the Myra mine yielded one of 83, which belonged to the Crown jewels of the Mogul. The real produce must be taken at double the official estimate. The Rajah has established an approximate average amount, and when this descends too low he seizes one of the supposed defaulters and beheads him or confiscates his goods. He sells his diamonds directly to Allahabad and Benares, and of late years he has established *ateliers* for cutting, fitted with horizontal wheels of steel worked by the foot.

Evidently here we have a primitive style, which has not varied since diamond-working began. Good pumps are required to drain the wet pits. Instead of sinking a succession of shafts, tunnels should be run along the veins of diamond-bearing rocks. Magnifying glasses and European superintendence would improve the washing. Evidently the yield would double in the hands of Brazilians or South-Africans.

The precious stone is still brought for sale from the nearer valley of the Krishna to Haydarábád: it occurs, I was assured, in a whitish conglomerate of lime locally called Gar-ka-pathar, which must be broken up and washed. During my week's visit I was consulted by two Parsee merchants concerning the rudimentary tests of scratching and specific gravity. In fact, at Golconda, where the finest gems used to be worked, no one, strange to say, can now recognise a rough diamond.

In the "Highlands of the Brazil" (ii., 113) I have given a detailed list of the various stones associated with the gem, and specimens of the Cascalho or diamond gravel, the Taua, the Canga, &c., have been sent to the Royal Society of Edinburgh by Mr. Swinton. It is advisable to remark that this association has everywhere been recognised. In Borneo we are told that "the diamond is known by the presence of sundry small flints." The gem-yielding pebble-conglomerate of India, not usually a breccia, as was proved by Franklin Newbold and Aytoun (*loc. cit.*, p. 386), contains quartz and various quartzose formations; garnet, corundum, epidote and Lydian stone; chalcedony and cornelian; jasper, of red, brown, bluish, and black hues; and hornstone, a kind of felspar, whilst "green quartz indicates the presence of the best stones." Fossil chert is yielded by the limestone, and the highly ferruginous and crystalline sandstone produces micaceous iron ores, small globular stones (pisoliths?), and almost invariably fragments of iron oxide. Finally, there are generally traces of gold, and sometimes of platinum. At Haydarábád I was assured that such was the case on the Krishna River, but none of my informants had any personal knowledge of washing. Dr. Carter's "Geological Papers" convinced me that the sandstones of the diamond area will be found to resemble the "Itacolumite," quartzose mica slate or laminated granular quartz, of Brazilian "Minas Geraes."

These considerations persuade me that diamond-digging in India generally, and especially in Golconda (the territory of Haydarábád), has been prematurely abandoned. In the seventeenth and eighteenth centuries the machinery for draining wet mines was not what it is now, and the imperfect appliances led to the general belief that all the deposits were purely superficial. Doubtless some of the deposits were in the alluvial soil of the most recent rocks, but M. Rosselet's account shows that deep digging may still be practised to advantage. Voysey also saw the "sandstone breccia" (diamond conglomerate ?) of Southern India "under 50 feet of sandstone, clay slate, and slaty limestone." The Brazilian miners ("Highlands," ii., 121) have only lately learned to descend 180 feet, and they find some of their best stones at the lowest horizon. The Vaal River and other South African washings, opened in 1868, soon reached 60 feet.

I had heard of chance diamonds being picked up by the accolents of the Krishna River, and Sir Salar Jung, with his usual liberality, proposed laying a dák for me to Raichor: he was ready, in fact, to meet my wishes in every possible way. I presently, however, learned from good authority that only crystalline rocks like those which I had seen in the Golconda tombs are produced by this central section of the Krishna, and that "Itacolumite" must be sought elsewhere. Evidently the precious stones have been rolled down from some unknown distance, and to follow the "spoor" demanded more time than I could command.

It is useless to insist upon the benefits of reviving the ancient industry. Haydarábád is not a rich country, and her trade is well nigh *nil*. But she has coal that wants only a market, and if to the "black diamond" she can add the white diamond, her future prospects are not to be despised. The first step is, of course, that of "prospecting," of systematically reconnoitring the ground, with the aid of a few experienced hands imported from the Brazils and South Africa. If the search be successful a company or companies would be soon found to do the rest. For me it will be glory enough to have restored the time-honoured "mines of Golconda."

We left at the week's end the country of "our faithful ally," greatly pleased with the courtesy and hospitality which seem to be its natural growth. And I have a conviction that, despite the inevitable retrograde party of all native states, the *codine* of the East,—the warlike Zemindars, the "dissolute vagabonds," the "Pathan bravos," and the "cut-throats and assassins" of the Press,—this realm has become since 1857 the "greatest Mohammedan power in India."

The return journey to Bombay gave time for other reflections. At present our "enormous dependency, India, the most populous and important that ever belonged to a nation, and conferring a higher *prestige* on the ruling race than has ever been conferred by any other subject people,"—as the judicial Trollope has it,—is, has been, and under present circumstances ever will be, somewhat neglected by the general public of England. No home Britisher can interest himself even moderately in such a colony. It is too distant, and it can hardly be brought nearer by local parliaments and similar institutions. Although "taxation without representation is tyranny," we are not yet prepared to grant what eventually must be granted, representative government. We are therefore driven to seek some other course.

At Haydarábád, as in India generally, we are living upon a volcano, which may or may not slumber for years. The remedies hitherto proposed for the natural disaffection of the great native powers, kept as they are in a state of quasi-tutelage, appear to be mere quackeries, likely to do harm rather than good. For instance, to make the energetic Indian Prince more powerful within his own jurisdiction would be simply to arm him against ourselves.

But why not at once admit a certain number to seats in the House of Lords? Of those who claim salutes of 21 guns there are, besides four foreigners, three Indian Princes,—the Nizam, the Gaikwár, and the Ruler of Mysore,—who all happen at present to be minors. Amongst those honoured by 19 guns we find Scindhia, Holkar, and Udepúr; whilst Jaipúr, with twelve others, has 17 guns. Of course it would be necessary to limit the number to six or seven, but the hope of eventually rising to the dignity should not be withheld from the chiefs of lower grade.

Nothing would tend more directly to conciliate the Princes of India, and to make them our firm friends, than to admit them to the highest dignity of the Empire,—to a House where they would doubtless hasten to sit, where they would learn their true interests, and where they would find themselves raised to a real instead of a false equality with the ruling race.

VI. CERTAIN PHASES OF BIRD-LIFE.

By Charles C. Abbott, M.D.

NOTWITHSTANDING so general an interest has been taken in studying the habits of our birds, by both scientific and amateur naturalists, there are several phases of bird-life to which little or no attention has been paid; at least scant reference, if any, has been made to them in ornithological literature.

One such feature of bird-life is the mode of acquiring the range of flight-power characteristic of each species. A careful and long-continued study of our birds in their chosen haunts, free from all unnatural (*i.e.*, human) persecution, has enabled me to detect but little variation in the flight-powers of the individuals of any species of bird observed—far less than in the general range of their habits; but still such individual variation, I think, does exist. A bird is not a perfectly-adapted machine, capable of faultlessly filling its destined place in Nature, and unerringly performing everything required of it. With the simple growth of the feathers of the wing there does not come the ability to fly. Just as creeping precedes walking, in children, this is a gradually-acquired power. The commencement may be termed "flapping," and consists in simply breaking the force of a descent; this is followed by a more effectual use of the wings, and horizontal progression, and it is some time subsequent to this that the young birds attain to the power of *upward* flight. This holds good of a considerable number of species, studied with special reference to their flight—as the robin, the wood-thrush, cedar-bird, cat-bird, pewee, and indigo-bird.

It is doubtful if young birds, while yet in their nests, are conscious of the use to be made of their wings. After long-continued experimenting, I find they make no use of them in endeavouring to escape, but trust to their legs entirely if removed from the nest, or defend themselves by pecking at the intruder. When a sufficient growth of feather has been obtained the parent-birds, directly and indirectly, instruct them, or, perhaps more properly, force them to use their wings. So, at least, I can only interpret certain habitual actions of the parent birds with reference to their newly-fledged young.

As an instance I will quote from my field-notes, with reference to the indigo-bird:—"June 23, 1873. Found a nest of this species in a dense thicket of blackberry, and, curiously enough, within just seven paces of the railroad-track. The young birds were just ready to leave the nest. I visited the nest the next day, and saw on my approach one of the four young birds sitting on a brier-stem, about a yard from the nest. Taking a favourable position, I continued to watch the birds closely, as they were very restless and noisy. Evidently something unusual had occurred or was occurring. In a few moments I saw the hen bird go to the nest, and push one of the young birds out of the nest. It forced it from the edge of the nest, to which it clung with its feet. Once free, the little fellow struggled to keep itself up, throwing *up* its wings, as a child would straighten out its arms when falling. This was the initial movement that developed into flight. All of the young birds were thus forced from the nest, and I am satisfied from no outside cause, as, for the three following evenings, the young returned to the nest to roost. I spent several hours watching this brood and their parents, and the whole time was occupied, except short intervals when they were fed, in forcing the young birds from point to point, but ever keeping them from the railroad-track, over which trains passed frequently. Two days from leaving the nest they could fly 6 or 8 yards, but always from a higher to a lower perch, and regained the more elevated branches by very short, 'jumping' flights, with a laborious flapping of the wings; but on the fifth day they could follow their parents almost any distance, and execute an upward flight with apparently the same ease. Examination of the wing-feathers on the 30th of June, as compared with a week previous, showed so slight gain in the growth of the feathers that I believe nothing in the increased flight-power was due to their being now better fledged."

Such observations as the one noted in detail I have so frequently repeated with widely-differing species as to satisfy me that what may be termed "direct instruction" in flight is given to the young birds by their parents. "Indirect instruction" also is noticeable, in the fact that the parent-birds cease to feed their young, and so force the latter to leave the nest and follow them. Once out of the nest they soon endeavour to walk on air, as it were, and, falling, open their wings, and, as described, thus take the initial step. This ceasing to bring the food to the young while yet in the nest is done in some instances, I judge, only to draw them from the nest; and then they feed them as before, but not as frequently, which leads the young to voluntarily move from point to point. The important fact must not be lost sight of, too, that the young birds, when once out of the nest, witness nearly every movement of their parents, and learn, undoubtedly, very much through imitation of their movements.

For these reasons I believe the acquisition of full-flight power is gradually acquired: first there is a mere "flapping" to prevent falling; then short horizontal stages of aërial progression; finally, a steady, intelligent use of the wings, enabling the birds to execute the highest type of flight within their capabilities, *i.e.*, upward flight.

In the case of birds of more complicated flight than those mentioned above, such as the falcons, where hovering is a necessary acquirement, the truth of the assertion that flight is gradually acquired becomes more evident from the fact (which I have very frequently verified by observation) that the young birds for some time after leaving the nest are fed by their parents. They commence procuring food for themselves by chasing sparrows; checking their moderate flight when above a thicket, they rush upon the fleeing birds, more frequently without success than with. Their first attempts at hovering are miserable failures, and it is not until autumn that they are enabled, by the complete control of their wings, to stay themselves in mid-air, and, at the proper moment, dart with unerring aim upon some luckless mouse.

I have used the term "unerring," because it is customary so to characterise this act of the falcons; but having watched, with a powerful field-glass, the hovering and darting of hawks, I have been forced to consider the term far from correct, and that not more than one-half, if as many, of the "strikes," on the part of the bird, are effectual.

Following the young birds, of any species, from the nests, and noting their movements, we find that the one prominent aim of their lives, during their first summer, is the acquisition of food. They have really nothing else to do, if we except escaping from the attacks of their enemies, and this is taught them directly by their parents. I judge that the great majority of birds that fall victims to birds of prey and carnivorous mammals are young. To return to the feeding-habits of birds:—These appear to be acquired, by every bird, through imitation of the movements of the parents when in search of food; judgment as to localities, on the part of the young, and allied circumstances connected with procuring food, come by experience. Watch a restless little creeper (*Certhia familiaris*), during chill winter mornings, as it flies from tree to tree and clambers over and about the rough bark. It seems, indeed, a mere automaton, driven, and not going of its own free will; but, if we continue our observations but a little longer, we shall find it really a discriminating creature, passing by certain trees that are to us all one with those visited. It is not chance, but a consciousness of the uselessness of search, that determines its flight to some more distant rather than a nearer tree.

As an example of the knowledge gained by young birds through imitation, let us take young woodpeckers. On leaving the nest they accompany their parents, but are not fed by them. Like the old birds, they immediately commence to climb the trunks and branches of the trees. Having been fed with insects when in the nest, they are already able to recognise their proper food, and devour the visible insects they may discover on the outer surface of the bark. Now, was it the example set by their parents, or the peculiar construction of their bill and feet, that was the cause of their having sought the trees and climbed over them in the peculiar manner common to their kind? I think, clearly the former. Now, merely clambering over the bark of trees would not enable them to secure sufficient food, and imitation could not extend beyond this point; but here experience comes into play, and the gradual acquirement of the whole routine is easily traced. The bark of trees is nearly always cracked, and in the crevices are more insects than on the surface, and the habit, soon acquired, of search in the cracks of the bark is the one step from searching over the exposed surface to search beneath. Imitation led the *ignorant* young bird to the thrifty growth of timber, and not to the tangled hedge-rows. Experience taught him the accustomed haunts of those insects on which Nature bids him prey. If we go back into the remote past, and recal the ancestral woodpecker, we can, with no undue use of the imagination, picture to ourselves the first steps that led the good climber to find in the half-decayed bark the nourishing food abounding there; and now let us return to the present, and seek for some variation in the habits of the birds of to-day. As an instance, the "flicker," or golden-winged woodpecker, leaves the timber-lands, and in loose flocks, often in company with robins, wanders over pasture-fields and meadows in search of food, more especially the crickets, and not under fences do they look for them, but under the dry droppings of the cattle. Here is an instance where accident, it may be, gave origin to—and experience has confirmed into—a habit, a decided variation from normal woodpecker life. Now, a young woodpecker leaving its nest June 1st, if dissociated from its kind, would never leave the woodlands, and, seeking the pasture-fields, overturn dry chips of cow-dung, in search of crickets; but such young birds will naturally follow their parents thither,—and this is just the case, for the larger proportion of birds killed in October, in such localities, are the young of the preceding summer.

In conclusion, with reference to young birds, I believe they leave their nests *totally ignorant*, and *naturally* imitate their parents. What this imitation secures to them, in the way of knowledge, they perfect by experience; and this explains the variation in the habits of the same birds, so noticeable when studied in localities widely distant and greatly differing in character.

Let us turn our attention now to adult birds; and, with reference to them, I would refer particularly to two phases of their life-habits that have interested me exceedingly. The first of these points is the ingenuity so frequently displayed in procuring food. By the exercise of ingenuity, I mean instances of the attacking bird (in cases of birds of prey) being at first outwitted by the pursued, and, after repeated efforts availing nothing, ceasing its aggressive movements; then considering the causes of failure, planning a new method of action, and, having correctly judged the difficulties, finally succeeding. This, at least, is the manner in which I interpret the following instance:—

While out watching our winter birds, January 22nd of this year, I was caught in quite a hard shower, and sought shelter under a group of three large, dense cedars. Like myself, driven in from the adjoining meadows by the increasing rain, came a dozen or more sparrows, which, settling among the branches, commenced dressing their feathers and twittering cheerily. In a few moments after came, with a rush and loud chirp, a gay cardinal. If the sparrows did not acknowledge his presence with a low bow, each, at any rate, took a lower branch, leaving him on his elevated perch like a monarch on his throne. But he was fated to be molested, for, scarcely had he become fairly settled, and his feathers smoothed, when a sparrow-hawk rushed through the tree, with a zigzag movement, endeavouring to seize him or one of his attendant sparrows. Failing in this, the hawk hovered about a few moments, giving the scattered birds time to return, which they quickly did, when, with a similar rush, he again scattered them. One little snow-bird was so thoroughly frightened that it lit upon my shoulder, as though seeking safety under the brim of my hat. The third effort of the hawk failing, he came back immediately and seated himself at a little distance from the top of the tree, and close to the main stem. I remained nearly motionless, but with upturned face, and could plainly see the bird, though fortunately I escaped notice. One thing in particular attracted my notice; the bird was very much exhausted—"out of breath," as we should say of ourselves—and, with his beak open, he panted violently. This satisfied me that the efforts to capture prey are not accomplished with the ease sometimes supposed. As the rain was increasing, and the wind considerable, the sparrows again collected in the tree; and now the hawk rushed *out* instead of in, and bore a luckless sparrow in his claws.

I think that we have here all that I claimed, when speaking of ingenuity on the part of adult birds in seeking their food. There was in the above instance a painful consciousness, at first, of failure to secure the desired prey; there was a determination to succeed, in spite of failure at the start, and a correct determination of the cause of failure, coupled with the invention of a plan by which the difficulties might be overcome. What more should be required to demonstrate that the mental powers of lower animals differ from those of man solely in degree?

Again, let us consider a case of ingenuity displayed by a bird in successfully avoiding an enemy. Here there is more cause to be surprised at the result, inasmuch as there was no cessation of the attack to give the pursued bird time for considering how best to act under the circumstances; but, while fleeing for life, it matured a plan of escape that happily succeeded. This instance of ingenuity on the part of a pursued bird I have already related ("Land and Water," March 2, 1872), but, considering it more remarkable than any other that has occurred to my knowledge, and having witnessed a repetition of it two years later, I again relate it in preference to other instances I have noted bearing upon the same subject. The case is that of a "king-rail" (*Rallus elegans*), which my spaniel flushed in open ground, the grass not being tall enough to conceal it. The bird trusted wholly to running, and kept clear of the dog; frequently it "doubled," and seemed to enjoy the chase; but, evidently becoming somewhat fatigued, as shown by the nearer approach of the spaniel, it ceased doubling, but, running in a straight line some distance, it allowed the dog to get within a foot or more, when it jumped, with a single flap of its wings, a foot or more from the ground; then dropping down quickly behind the dog, it turned and ran in the opposite direction, gaining considerable ground before the impetuous spaniel could check its speed, turn about, and follow. Here, again, as we would express it in describing any human experience, "the circumstances of the case were taken into consideration" by the pursued bird, and, without taking to flight, as would seem the more natural act, it surmounted the difficulties and effected its escape. I can conceive of no other way of explaining this action of the rail-bird than by admitting that a train of thought passed through the brain of the bird—that it thought, "If I gain time, I am safe," just as any pursued person would think that, if he could reach some spot, be heard, &c., he would be safe. And, while yet running at great speed, the bird *thought* of an ingenious plan by which it *did* gain time and reached the reedy creek-bank in safety.

It might be argued that a single act of a bird at some one time and under peculiar circumstances does not constitute a habit—that it simply chanced to do so and so; but a second occurrence of the kind would result differently. It must be remembered, however, that where a bird is noticed in its natural haunts once, even if for more than an hour—which is an unusually long observation—there are weeks when this same bird is unseen, and therefore what its acts may be are absolutely unknown. For this reason, an ingenious act of a bird may be frequently repeated, and almost certainly is. Indeed, our ignorance of bird-life is so great, that what seem to us "curious instances," because but seldom witnessed, are frequently daily occurrences and ordinary features of the bird's life. It can scarcely have escaped the notice of close observers of our winter birds that their comparative abundance is only during clear, pleasant weather, when they will be as lively and restless as spring birds in early summer, and that during the winter certain localities, as the southern outlooks of wooded hillsides and such sheltered spots, are those where these hardy species "most do congregate." During a mild day at some such spot we can almost delude ourselves into thinking that spring is coming; but on the morrow a fierce wind rattles the bare branches above you, clouds of stinging dust or driving snow fill the chilled air, and not a bird is to be seen or heard, the cheery sights and sounds of yesterday having given place to a dreariness most drear. One question now arises, and we naturally ask, "What has become of the birds so lately here?"

During the winter of 1874-75 (the coldest except one—1835-36—since 1780) I endeavoured to determine to what extent these birds sought shelter, and the character of it, not only as a protection against severe storms, but as regular winter quarters—*i.e.*, for roosting-places. I was led to do this from the fact that these winter residents, as the bluebird, the cardinal redbird, and the titmouse, do not roost in the trees, as in summer, and it seemed probable that, seeking warmer quarters in ordinary weather, they should seek shelter from severe storms, and not temporarily migrate to some point beyond the limits of the storm; not only this, but that some spot is selected early in the season as such roosting-place and refuge, and occupied as such throughout the season. So far as my observations extend, I was correct in my surmises.

I have on my farm a deep "gully," or ravine, thickly wooded, and with overhanging banks, extending a considerable portion of the entire length. This overhanging earth is held in place partly by the character of the soil, and more by the roots of the trees growing near the margins of the gully. In this locality, under the overhanging earth, in some instances at a distance of 3 feet from the open ground, I found the snow-birds, song and chipping sparrows, occasionally a flock of cedar-birds, the arctic snow-bird, and horned larks roosting; and, judging from the amount of excreta upon the ground, this had been the accustomed roosting-place for many weeks. A little before sundown, during January, I would find these birds, some or all of of them, congregating in the adjoining fields and in the trees of the gully, and quite suddenly they would all disappear. Searching every possible hiding-place, I finally found them as above described. If the following day proved very cold or stormy, many of them would remain in their snug retreat, the arctic visitors being the first to venture out. The birds just mentioned all build open nests, either in trees or upon the ground. On the other hand, the titmouse, nuthatch, brown tree-creeper, and bluebird, all of which build nests in hollow trees or sheltered spots of that character, I found regularly roosted in the hollow trees or in the outbuildings of the farm. The cardinal redbirds, however, which nest in trees and brier-patches, usually took refuge in dense cedars to roost, but sought other shelter during severe storms. For instance, during the remarkable wind-storm of February 9th, when the air was filled with dust, and the thermometer ranged from 3° to 4½° F., no ordinary shelter could protect our resident birds. During the day not one was to be seen flying. I found the cardinal redbirds—a pair of them—had taken shelter in a large hollow tree, and with them was quite a large number of titmice, a brown tree-creeper (*Certhia familiaris*), and several sparrows. I do not doubt but that the earth-shelter already described had proved inadequate, and that the birds usually roosting there had sought more sheltered spots. However, I did not have the courage to face the wind and see for myself if such was the case.

During the present winter I have found that some, at least, of our winter birds utilise the very excellent shelter afforded by the nests of our bank-swallows. February 20th, a bright, clear day, I passed by a high, steep cliff of compact sand and clay, much frequented by these swallows during summer. I noticed there chipping-sparrows and a bluebird sunning themselves, each at the opening of a nest. On driving them away I found that they circled about for a few moments and returned. On passing the cliff again some hours later, I saw these birds and several others, some at the openings of the nests, and others flitting about, quite in the manner of swallows. I could not reach the nests to determine if they had been much occupied during the winter, but do not doubt but that such was the case.

I have not found, however, any shelters constructed by birds for such purpose solely, except in the case of the introduced English sparrow, which builds quite an elaborate and very warm roosting-nest. During the early frosts of autumn and prevalence of cold rain-storms occurring before the ordinary date of migratorial departure, the nests used in spring and summer are, I know, used as roosting-places, but I have not detected any refitting of them for this purpose. Considering this, it would be natural for birds to build new structures for winter use, and in the sparrow we have an instance of it, and, I presume, the abundance of natural shelter has alone prevented the gradual acquirement of this habit by our winter birds.

Having familiarised one's self with the various phases of bird-life as it occurs in the open fields, dense thickets, along secluded streams, and in shady forests, one can scarcely conclude otherwise, if happily he has not entered upon his studies with some preconceived notion, than that these wild and wary falcons, timid sparrows, fiery little wrens, and cautious waterfowl are creatures that, like man himself, are thrown upon the world dependent upon their own exertions, guided by their own reasoning powers. There are no prearranged rules which, when birds leave their nests, they must strictly follow to exist. Given that knowledge which comes through direct and indirect instruction from the parent-birds, and a young bird, having the world before it, exercises just those mental powers that man exercises, but limited just so far as its own wants are less than man's wants as man. Finally, in the chance occurrence of some peculiar habit, have we not a trace of the former mode of life of some far-distant ancestral form; and, in the undeniable irregularity of all habits, can we not discern unmistakable indications of the gradual adoption of every habit, just as the various specific forms themselves gradually emerged from the archaic creature that, appearing in the dim past, foreshadowed the gigantic condor of the Andes, and the petulant humming-birds of our summer gardens?

VII. THE LOAN COLLECTION OF SCIENTIFIC APPARATUS AT SOUTH KENSINGTON.

THE English Government seems, at last, as if it were becoming alive to the fact that the wealth and commercial prosperity of the country are, to a large extent, due to the discoveries and researches of scientific men. While the respective Governments of America, France, Germany, and other countries have established scientific universities, and recognised in numerous ways the claims of scientific workers, the prosecution of all branches of scientific research in England has been almost entirely left to private enterprise. But we suppose we may take the present Exhibition of Scientific Apparatus as a proof that Science will henceforth have its position acknowledged in the deliberations of the Government of England, and receive some small share of the money expended for the honour and welfare of the country. The great success of the present Exhibition has been widely proclaimed by the whole of the public press. Some journals have, it is true, doubted the advantage of bringing from a distance instruments of mere historic value: if, however, they are the means of recalling to the minds of our legislators and the public generally the splendid discoveries of the men who used them, and the part they played in the advance of civilisation, then, indeed, were this the only good result of the Exhibition, it would have served a great and important end. Had no adventitious means been adopted to arouse the interest of the public in the various instruments, the practical value of the Exhibition—excepting to scientific men—would, perhaps, have been an open question; but it is only necessary to attend the evening lectures which have been so kindly undertaken by eminent scientific men, and notice the eagerness with which the large audiences listen to the lectures, to be convinced that the object in visiting the Exhibition is the desire for knowledge, and not mere idle curiosity. The demonstrations, too, were attended by considerable numbers of people, and whatever instrument happened to be under demonstration—whether Radiometers, or Dr. Siemens's Bathometer and Attraction Meter, or M. Pictet's machine for the production of Artificial Ice—questions were freely asked, until the construction and mode of action of the instrument were understood. In the present number we have only sufficient space to refer briefly to the more important of the historical instruments used in chemical and physical researches.

CHEMISTRY.

In the Chemistry Section there is exhibited the apparatus employed by John Dalton in his Researches. The following description of this Series has been contributed by Prof. Roscoe, F.R.S.:—

The apparatus employed by John Dalton in his classical researches, whether physical or chemical, was of the simplest, and even of the rudest, character. Most of it was made with his own hands, and that which is to be exhibited has been chosen as illustrating this fact, and as indicating the genius which with so insignificant and incomplete an experimental equipment was able to produce such great results. The Society has in its possession a large quantity of apparatus used by Dalton, most of which, however, consists of electrical apparatus, models of mechanical powers, models of steam-engines, air-pumps, a Gregorian telescope, and other apparatus of a similar kind, which was either bought or presented to him. It has not been thought necessary to exhibit these, but rather to show the home-made apparatus with which Dalton obtained his most remarkable results.

I. *Meteorological and Physical Apparatus made and used by Dr. Dalton.*

Throughout his life Dalton devoted much time and attention to the study of meteorology; indeed his first work, published in 1793, was entitled "Meteorological Observations and Essays," and his last paper, printed in 1842 (Mem. Lit. and Phil. Soc., vi., 617) consists of auroral observations. Hence the first of Dalton's apparatus which claim attention are the meteorological instruments.

No. 1 is Dalton's mountain barometer, with accompanying thermometer, made for him by the late Mr. Lawrence Buchan, of Manchester. The barometer is enclosed in a wooden case, which Dalton was accustomed to carry in his hand.

Several home-made barometers used by Dalton in his observations are in possession of the Society. They are all of them filled, and the scales prepared, by Dalton himself, and are simple syphon tubes with a bulb blown on at the bottom to serve as a mercury reservoir. These are attached to plain pieces of deal, upon the upper part of which the paper scale is pasted. One of these, which has probably also served for tension experiments (No. 2, has been placed in the collection.

Many of the thermometers appear also to have been home-made.

No. 3 is a mercurial thermometer, evidently made and graduated by Dr. Dalton, and marked with his initials, J. D. The freezing-point of this thermometer was tested recently by Mr. Baxendell, who found that it had not altered since the instrument was graduated.

Another (No. 4) is of the same kind, and bears date 1823.

No. 5 is a third mercurial thermometer with long stem and wooden scale.

No. 6 is an alcohol thermometer with wooden scale.

No 7, a registering maximum and minimum thermometer employed by Dalton; maker's name, J. Renchetti, 29, Balloon Street, Manchester.

II. *Apparatus constructed and used by Dalton in his Researches.*

(1) "On the Constitution of Mixed Gases," (2) "On the Force of Steam or Vapour from Water or other Liquids at Different Temperatures, both in a Torricellian Vacuum and in Air," (3) "On Evaporation," and (4) "On the Expansion of Gases by Heat" (by John Dalton, "Mem. Lit. and Phil. Soc. of Manchester," 1st series, vol. v., part 2).

No. 8 is an apparatus used for the determination of the tension of volatile liquids at low temperatures; it consists of a syphon tube, at the upper end of which is a scale in inches in Dalton's handwriting. He describes it thus:—"I took a barometer tube 45 inches in length, and, having sealed it hermetically at one end, bent it into a syphon shape, making the legs parallel, the one that was closed being 9 inches long, the other 36 inches. I then conveyed two or three drops of ether to the end of the closed leg, and filled the rest of the tube with mercury, except about 10 inches at the open end. This done, I immersed the whole of the short leg containing the ether into a tall glass containing hot water."

No. 9 is a smaller tube containing another liquid, also having a graduated scale written on paper and attached to the tube.

Nos. 10, 11, 12, 13, 14, are tubes used by Dalton for measuring the tension of vapour from water and other liquids at higher temperatures than their boiling-points, both in a vacuum and air.

No. 15 is a tube used by Dalton for measuring the tension of the vapour of bisulphide of carbon, labelled "Sulphuret carb.," with a paper scale in Dalton's handwriting, and a cork showing that the upper portion of the tube containing the bisulphide of carbon could be heated in a water-bath to various temperatures.

No. 16 is a manometer tube, fixed into a board, divided and numbered by Dalton.

No. 17 is an apparatus used by Dalton for the determination of the tension of the vapour of ether, and is interesting as being the instrument by means of which Dalton arrived at one of his most important experimental laws. It is described as follows (p. 564):—"The ether I used boiled in the open air at 102°. I filled a barometer tube with mercury moistened by agitation in ether; after a few minutes a portion of the ether rose to the top of the mercurial column, and the height of the column became stationary. When the whole had acquired the temperature of the room (62°) the mercury stood at 17·00 inches, the barometer being at the same time 29·75 inches. Hence the force of the vapour from ether at 62° is equal to 12·74 of aqueous vapour at 172° temperature, which are 40° from the respective boiling-points of the liquids." This is generally known as Dalton's law of tensions, since shown by Regnault not to be rigorously true.

No. 18 is a wet and dry bulb mercurial thermometer made by H. H. Watson, of Bolton.

III. *Apparatus for measuring Gases and for determining the Solubility of Gases in Water.*

No. 19 is an apparatus with a graduated tube, probably used by Dalton for the determination of the laws regulating "The Absorption of Gases by Water and other Liquids," read October 21st, 1803 ("Manchester Memoirs," 2nd Series, vol. i.).

No. 20 is a graduated glass tube attached to a bottle of india-rubber, also probably used in his researches on the absorption of gases by water.

No. 21, No. 22, are divided eudiometer tubes, employed by Dalton for measuring the volumes of gases.

No. 23 is a spark eudiometer.

Nos. 24, 25, 26 are glass tubes, pipettes, and funnels, graduated by Dr. Dalton and used by him for measuring gases.

No. 27 is a graduated glass bell-jar, used for measuring gases.

No. 28 is a phial, with graduated tube attached by cement, for collecting and measuring gases.

Nos. 29, 30 are stoppered phials, with the bottoms cut off, used as gas jars for collecting and measuring gases.

No. 31 is 1000 grains specific gravity bottle, with its counterpoise of lead stamped "175" by Dalton, and paper labelled in his handwriting "bottle balance."

No. 32 is a pipette.

No. 33, square bottle of thin glass, fitted with brass caps, and probably used for the determination of the specific gravities of gases.

No. 34 is an earthenware cup, used by Dalton as a mercury-trough, and containing a small phial with mercury.

Nos. 35, 36 are bulb tubes, with graduated scales, serving for the determination of the coefficients of expansion of gases.

No. 37 is a Florence flask with cork and valve for determining the specific gravity of gases.

No. 38 is a glass alembic.

IV. *Weights, Balances, Apparatus, Reagents, and Specimens used by Dalton.*

No. 39, eleven phials, containing creosote, iodine, amalgam of bismuth and mercury, quercitron bark, grana sylvestra, cochineal, and other substances, labelled in Dalton's handwriting.

No. 40, three divided blocks, used by Dalton for the illustration of his lectures: these are not, however, the balls an inch in diameter (referred to in his latest memoir on the "Analysis of Sugar") which he employed occasionally in his lectures, as illustrating his newly-discovered laws of combination and the atomic theory; these appear, unfortunately, to be no longer in existence.

No. 41 is a common pair of scales used by Dalton.

No. 42, a pair of apothecary's scales and weights employed by Dalton, with a paper of weights made of wire, labelled in his handwriting "100th grains."

No. 43 is a box of weights used by Dalton, and containing a pill-box labelled "Platina," another pill-box labelled "Hund," and containing 100th of grains, and another wooden box containing brass gramme weights, labelled "Weights, French;" the other ordinary weights are of lead.

No. 44 is Dalton's pocket-balance, consisting of a small pair of apothecaries' scales, with beam about 4 inches long, and having the pans attached by common string; it is contained in a tin case for the pocket.

No. 45 is a penholder used by Dalton.

No. 46, leaden grain weights made by Dalton from sheet lead, and stamped in numbers by him.

No. 47, iron punches used by Dalton for this purpose.

No. 48, a glass lens, wrapped in a piece of paper, labelled in Dalton's writing "Sun's focus 4·2 inches."

No. 49 is a paper containing "10th of grains," made by Dr. Dalton of iron wire. The paper in which these are wrapped is part of a note from one of Dr. Dalton's pupils (as is well known he lived by teaching mathematics at half-a-crown per lesson), in which the writer presents his "compliments to Mr. Dalton, and is sorry that he will not be able to wait upon him to-day, as he is going to Liverpool with a few friends who are trying the railway for the first time. Mr. D. may fully expect him on Monday at the usual time."

No. 50 are bottles of tin, earthenware, and silver, some of them being common penny pot ink-bottles. Each has a thermometer tube cemented into the neck of the bottle, and these tubes are provided with paper scales. These were used by Dalton probably for experiments on radiant heat.

No. 51 is a manometer tube used by Dalton: it consists of a tin vessel attached on either side to leaden tubing, and having a thermometer tube closed at the upper end, and provided with a divided scale, fixed into the upper portion of the tin vessel.

No. 52, Dalton's Balance, made by Accum, and capable of arrangement as hydrostatic balance with weights and counterpoises.

This section also contains :—

Balance used by Cavendish.—This balance, of rude exterior but singular perfection, was made by Harrison, according to the plan and by order of Henry Cavendish, and passed at his death to his cousin and heir, Lord George Cavendish. By him it was presented to Sir Humphry Davy, together with the greater part of Mr. Cavendish's philosophical apparatus. Presented to the Royal Institution of Great Britain by Mr. Felix R. Carden.

Balance used by Dr. Thomas Young and Sir Humphry Davy.—A balance made by Fidler for the Royal Institution.

Balance used by Sir Humphry Davy.—Presented to Prof. Roscoe by Mrs. F. Crace-Calvert.

Balance used in his experiments by Dr. Joseph Black, Professor of Chemistry in the University of Edinburgh, from 1766 to 1799.

Pneumatic trough used in his experiments by Dr. Joseph Black.

Glass chemical vessels (retort, bottle, and flask or receiver) used in the chemical laboratory of the University of Edinburgh during the latter half of last century, showing the contrast between them and vessels used for similar purposes at the present day.

Apparatus employed by the late Thomas Graham, F.R.S., Master of the Mint, in his principal researches between the years 1834 and 1866. The series is interesting as showing the simplicity of the appliances with which Graham worked, and by the aid of which he discovered facts and established laws which have since proved to be of so much importance.

Old cupellation furnace, supposed to have been the one used by Sir Isaac Newton, when Master of the Mint, in some experiments on the cupellation of silver.

Touchstone for the assay of gold, formerly used in the Royal Mint.—The method is based on the fact that the greater the amount of gold contained in an alloy, the brighter is the gold-yellow colour of a streak drawn with it on a black ground, and the less is it attacked by pure nitric acid or by a "test" acid. In ascertaining the richness of the alloy under examination its streak is compared with marks drawn with alloys whose richness is accurately known.

Apparatus used by Faraday for the condensation and liquefaction of Gases, consisting of condensing pump and connections, conducting and other tubes, gauges, sealed tubes for containing the liquefied gases, &c.

Original tubes containing gases liquefied by Faraday.

In the department of PHYSICS we find :—

Original apparatus with which Faraday obtained the magneto-electric spark.—A welded ring of soft iron, 6 inches in diameter, 7-8ths of an inch thick, one part covered by a helix A containing about 70 feet of insulated copper-wire, occupying about 9 inches in length upon the ring. The other part covered by a second helix B containing about 60 feet of insulated copper-wire. The helices are separated from each other at their extremities by ½ an inch of the uncovered iron. The iron ring was converted into a magnet by passing a voltaic current through the helix A. This induced an electric current in the helix B, and a small spark was for a moment seen at the carbon terminals.

Faraday's original apparatus for magneto-electric induction by a permanent magnet.—A pasteboard tube is surrounded by a helix C of insulated copper-wire. The diameter of the tube allows a cylindrical bar magnet to pass freely into it. The terminal wires of the helix are connected with a galvanometer. On the introduction of a permanent bar magnet into the helix, and on its withdrawal from it, currents of electricity were induced in the helix which caused a deflection of the galvanometer needle.

Faraday's rotating rectangle, for illustrating the inductive action of the earth.—The wire rectangle provided with a commutator for collecting the currents was attached to a galvanometer, and rotated in the line of the magnetic meridian, the electric current induced in the rectangle deflecting the galvanometer needle.

Various helices, spirals, &c., used by Faraday in his researches on magneto-electric induction, &c.

A magnet made by static electricity, with note by Faraday.—"A magnet made at the Royal Institution by an electric discharge from 70 square feet of charged surface. Present, Sir H. Davy, Pepys Jordan, Bostock, and Faraday."

Portion of the battery used by Sir Humphry Davy in decomposing the alkalies.

Diagrams of magnetic curves, prepared by Faraday.

Coils and helices, used by Faraday in his electro-magnetic researches.

Model frequently used by Faraday during his researches on the rotation of a ray of polarised light by electricity and magnetism.

Block of glass pierced by sparks from an induction-coil. Presented to Faraday by M. Ruhmkorff, 1861.

Glass tubes prepared by Faraday for testing the magnetic and diamagnetic character of gases.—The tubes containing the gas to be examined were suspended in the magnetic field of a powerful magnet, the result being either attraction or repulsion of the tubes as the gases they contained were either magnetic or diamagnetic.

Bars of borate of lead glass, made and used by Faraday, for the action of magnets on polarised light.

The diamagnetic box of Faraday, containing spheres, cubes, and bars of diamagnetic metals; tubes of various liquids, bars of borate of lead, glass, various crystals, cradles, supports, &c., used by Faraday in his researches on diamagnetism.

Siberian loadstone and spark apparatus.—This was the loadstone employed by Faraday in his experiments on magneto-electric induction, from which he first obtained the induction spark.

Glass globes for producing electricity by rubbing with the hand. The globes are caused to revolve by means of multiplying wheels and a band of rope. The globes may be exhausted when they become luminous; the greatest amount of electricity or "fire" was obtained from them when they were exhausted. In the one with a large brass cap a small wooden disc could be inserted with threads distributed round its edge; when the glass was excited the threads stood out from the edge of the disc. Constructed about A.D. 1720.—(Museum of King George III., King's College, London.)

Daniell's battery, employed in researches by Prof. Daniell.

Early voltaic batteries:—Babington's, Cruikshank's, Wollaston's, and Sturgeon's.

Hare's calorimotor, or deflagrator.

Gas voltaic battery, devised by W. R. Grove, M.A., F.R.S., Professor of Experimental Philosophy in the London Institution, and described by him in a communication read before the Royal Society, May 11th, 1843.

A constant gas voltaic battery, also devised by W. R. Grove, M.A., F.R.S., and described by him in a communication to the Royal Society, dated May 30th, 1845.

Apparatus by which Forbes produced an induction spark from a natural magnet.

"Thunder house," or model to illustrate tbe identity of lightning and electricity, and the use of lightning conductors in protecting buildings,—said to be the first model of the kind, and to have been made by Dr. Priestly.

Apparatus erected in the equatorial room of the Kew

Observatory, in 1843, by Ronalds, for the purpose of observing atmospheric electricity, consisting of a principal conductor, with its glass support, umbrella, and heating apparatus; its voltaic collecting lantern; Volta's electrometers and sights; a Henley electrometer; a Gourgon galvanometer; a discharger, or spark measurer; and a Bennet's gold-leaf electroscope.

Early rheostat, given by Faraday to Sir Charles Wheatstone.

The original Wheatstone's bridge.

Cooke and Wheatstone's earliest needle instrument, 1837. —The letters are indicated by the convergence of two needles. The five line-wires required for the instrument were inserted in grooves in a triangular piece of wood, and wire laid underground.

Original five-needle telegraph dial.—(Wheatstone Collection of Physical Apparatus, King's College, London.)

Three A B C telegraph-sending instruments, showing gradual improvements.

First electric key, constructed by Sir Charles Wheatstone.

Wheatstone's first relay instrument.

Two early forms of stereoscope.—(Wheatstone Collection of Physical Apparatus, King's College, London.)

Jewel lens (ruby) of 1-60th inch focus.—Produced by Mr. Andrew Pritchard, at the suggestion of Sir David Brewster.

Brewster's patent kaleidoscope (with case).—The original form of the instrument made by Bate, of London, in the year 1815.

Otto von Guericke's original air-pump.

Air-pump wlth two barrels.—The first pump of the kind ever constructed. It is an exhausting and a condensing pump, and was made for King George III. in 1761.

Original spirit thermometer, of the Florentine Accademia del Cimento (17th century).—Presented to the Royal Institution by Sir Henry Holland, Bart., F.R.S.

Wedgwood's pyrometer, invented in 1782.—Dry clay when exposed to high temperatures contracts uniformly, and Wedgwood believed that by the amount of contraction the temperature which produced it could be measured. The instrument, however, is not reliable. This specimen was made by Josiah Wedgwood, and presented to the Edinburgh Museum by his grandson, Mr. Godfrey Wedgwood.

Daniell's pyrometer, employed in researches by Professor Daniell.

ASTRONOMY.

Objects illustrating the History of the Telescope and Astronomical Observation.

Incomplete telescope with broken lens of Galileo.
Compass of Galileo.
Magnet of Galileo.
Telescope of Galileo.
Object-glass (broken) of Galileo.
Telescope of Torricelli.
Tube of Torricelli.
Telescope of Diviani.
Telescope of Mariani.
Telescope of Campani.
Telescope by Amici.
Lens by Benedetto Bryhens.
" Primo mobile " of Ignazio Dante.
Quadrant of Cosimo I.
Quadrant of Giusti.
Compass of Antonio Blaichini.
Graphometer of Botti.
Registering thermometer of Fontani.
Natural magnet of the Accademia del Cimento.

Telescope, by Chr. Huyghens. The objective ground and polished by him, and bearing his signature.

Terrestrial refractor, made by Van Deyl, at Amsterdam, in the year 1781.

The Herschel 7-foot telescope. The original instrument constructed by Sir W. Herschel.—The tube is 7 inches in diameter and 7 feet long. Both mirrors were finished by Sir W. Herschel himself; they are sound and whole, but are much tarnished, and the large mirror was damaged in a fire some years since. The framework of the stand is entire, but the moving screws, cords, &c., are useless in their present condition.

A 10-ft. Newtonian reflecting telescope, made by Sir Wm. Herschel in 1812, with 8½-inch large mirror, small plane reflecting mirror, and several eye-pieces of various powers.

Objectives and eye-pieces of the 17th and 18th centuries, the greater part of which were ground and polished by Christian and Constantine Huyghens.

Apparatus used by Baily in repeating the Cavendish experiment.

NOTICES OF BOOKS.

Religion and Science; their Relations to Each Other at the Present Day. By STANLEY T. GIBSON, B.D. London: Longmans, Green, and Co.

IN this work an interesting and delicate subject is handled with a rare amount of breadth, liberality, and candour. The reconciliation of religion and science is attracting much attention, and is being discussed from very various points of view. But may we not put a preliminary question as to the nature of the feud for which a remedy is sought? Are religion and science essentially and permanently hostile? We think not: the differences between them seem to us to spring from merely incidental causes, and to have been intensified by the conduct of injudicious partisans. There are, on the one hand, men of an anti theological turn of mind, who eagerly watch the results of research in the hope of finding some fact or some conclusion which may serve them as a weapon against religion, and who claim—sometimes with very questionable authority—to speak in the name of science. There are men, on the other hand, of decidedly theological leanings, who scrutinise the career of discovery with equal attention, but with an opposite feeling, jealous lest either fact or theory should operate to the prejudice of religion. To take a recent instance, the Darwinian controversy has been needlessly obscured by outsiders of these two classes, the one hoping and the other fearing that the doctrine of Evolution—or at any rate that of Natural Selection—might shake some of the fundamentals of Christianity. More judicious minds, however, could not fail to perceive that Evolution, even when extended to the human race, is no less compatible with theism than was the old notion of special creation. We say that every individual plant and animal is created by God, even though we know it has been procreated by antecedent beings of its own species. In a manner closely analogous, we may still maintain that every animal and vegetable species has been created by God, even though we discover that it has been evolved from some earlier form of organic life. Evolution may be regarded as a mode of creation, not a distinct and irreconcilable process.

Another cause of discord between science and religion may be sought in the circumstance that the sacred writings of most religions open with a cosmogony, and contain passages which may be taken as deliverances on various physical and biological questions. Upon these cosmogonies and these passages theologians still, in some quarters, consider themselves entitled to build up philosophies which are in glaring contradiction to facts.

For this evil the true remedy was pointed out long ago by Giordano Bruno, and afterwards still more clearly by Galileo. These two great reformers maintained that all such passages express merely the opinions common at the times when the Scriptures were written, and were never intended as a physical revelation. We need scarcely say that this judicious view has been rejected by so-called "infidel" writers quite as decidedly as by ecclesiastics. The latter declare that Science and the Bible are at variance, and that science therefore is to be denounced and execrated. The anti-theologians, equally asserting that Science and the Bible differ, infer that the latter is therefore worthless as a moral and spiritual revelation. But religionists of a deeper and wider insight, who can discriminate between the unchanging essence and the varying form of divine truth, and men of science who profess not to be wise above what is demonstrated, see that these discrepancies and contradictions are of little moment. The first step, therefore, in this great reconciliation is of a practical character. Let us not over-rate the functions of the imagination in matters of science. Let us view the sacred cosmogonies as epical versions of the one great truth,—confirmed, as our author shows, by some of the most splendid results of modern discovery,—that "in the beginning God created the heaven and the earth," and let us not recognise, as the authorised and responsible interpreters of Science, men who have comprehended little of her doctrines and less of her methods.

Mr. Gibson's work consists of three essays, treating respectively on the belief in God, on the miraculous evidences of Christianity, and on the relation of the Gospel to the moral faculty in man.

In the first of these essays the author admits that the Design argument, "once so popular" and deemed so conclusive, no longer holds its former position, "at least with the educated classes." Some of the objections which it suggests are here stated with great force. It is admitted that on Paleyan principles, if consistently carried out, the designer and contriver of the universe must himself have been in turn designed, and so on *ad infinitum*. It is further conceded that from effects which, however great, are still finite, we are not justified in assuming an infinite cause. The argument is further met by the answer "there are multitudes of things in the world which do not appear to be the work of infinite wisdom and goodness, or indeed of wisdom and goodness at all." If Paleyans reply that "Were we but wiser we should see wisdom everywhere," they lay themselves open to the retort that "Were we wiser the result might just as likely be the very opposite. Man finds a wise arrangement in the properties which render the sheep, the ox, and the horse subservient to his purposes. But when he reflects on adaptations which render him liable to be devoured by the tiger, fatally bitten by the cobra, perforated and ulcerated by the chigoe and by *Lucilia humanivora*, he dismisses the matter as inscrutable. It has generally been assumed, in the Design argument, that contrivance must necessarily be the result of self-conscious intelligence. But it is admitted by some that much of man's intellectual action is unconscious. One eminent author goes so far as to maintain that all animals except man are invariably unconscious of their own activity. To the Paleyan, then, declaring that design implies an intelligent designer, it may be replied—"Yes, but who tells you whether this designer is conscious or unconscious?"

By far the most convincing argument for the existence of God is one which has been elaborated by modern science, and which depends on the tendency of all natural forces to come to an equilibrium. Hence we argue that the universe cannot have existed from all eternity, but must have had a beginning in time. Such a beginning, as far as we can conceive, involves the existence and intervention of God. Without such intervention, also, it seems difficult to account for the first appearance of life upon our globe. The experiments made to determine whether spontaneous generation is possible in solutions or decoctions of organic matter,—such as turnips, hay, or cheese,—however ingenious, are all beside the question. Before organic life had prevailed upon our earth, there could be no organic matter in existence. The advocates of abiogenesis, to establish their case, must be able to produce Bacteria, or some other low form of organic life, from inorganic matter.

Great weight is laid by Prof. Clerk Maxwell upon the properties of atoms as a proof of creation. In his Bradford lecture (1873), quoted in the work before us, he declares that "We are unable to ascribe either the existence of the molecules or the identity of their properties to the operation of any of the causes which we call natural." He agrees with Sir John Herschel that "the exact equality of each molecule to all others of the same kind gives it the essential character of a manufactured article, and precludes the idea of its being eternal and self-existent." But if atoms are manufactured articles, where and what is the raw material? The argument of Prof. Clerk Maxwell assumes too much. The bodies called elementary have a merely provisional right to this character; but the decomposition of a supposed element means a division of its molecules. There is, again, one circumstance which seems to point to the disappearance of atoms by a process somewhat analogous to the extinction of organic species. Looking over a table of atomic weights, we find certain gaps in the series, as if links formerly existing had been lost. Nor do we see that the idea of atoms being "eternal and self-existent" is in any way precluded. The author here remarks—"If it be granted that with our present knowledge we can point to no natural agency that would modify or produce the character of an atom, are we therefore justified in saying that no such agency ever existed? Because we do not know the natural cause of any phenomenon—nay, if you will, cannot conjecture how it could have had a natural cause at all—is it safe at once to pronounce it supernatural?"

Mr. Gibson holds that modern science has, at any rate, the merit of rendering polytheism an impossibility. We are not sure that the compliment can be accepted. We may, indeed, in view of the identity both in matter and in forces which we have succeeded in tracing far beyond the limits of our own planet, admit that the idea of conflicting territorial deities can no longer be entertained. But just as in a State unity of law, of institutions, of language and manners, may prevail equally under a personal despotism, a constitutional monarchy, or a republic, so the homogeneity which we detect in the universe supplies no absolute proof as to whether it is ruled by One or by many.

Into the interesting critique on the "Unseen Universe," and the discussion on that old and vexed question the Origin of Evil, we cannot now enter.

The second essay, on the "Miraculous Evidences of Christianity," can scarcely be dealt with in these pages. But the section on Miracles, so-called, said to have occurred subsequently to the age of the primitive church, and even down to our own times, is profoundly interesting. "There must," says the author, "one would say, be some unknown principle, either psychical or physical, to account for kindred narratives springing up in quarters so remote; and surely we may add the reflection that, with such accounts so attested at the present day among ourselves, it must be hard to establish an exclusive case for the miraculous in Judæa eighteen centuries ago." He adds, however,—"We may also deem it probable that there are ill-understood powers of nature which at times simulate the miraculous."

It is not too much to say that if all divines were like Mr. Gibson the antagonism between religion and science which he endeavours to remove would scarcely have come into existence.

The Variation of Animals and Plants under Domestication. By Charles Darwin, F.R.S. Second Edition, Revised. London: John Murray.

To give a formal critique of this work would be impossible without entering upon the entire debate between the author on the one hand and the anti-evolutionists and catastrophic evolutionists on the other, a task which, for obvious reasons, is here out of the question. The author informs us that since the appearance of the first edition of the work, in 1868, he has accumulated a large body of additional facts, the more important of which have been made use of to strengthen the argument. Doubtful statements have been omitted, and certain errors discovered by critics have been eliminated. The value of the work has thus been greatly increased. Even those who feel or affect a horror at the very name of the illustrious author cannot, we think, deny that he has laid before the world in this, as in his other books, a store of valuable facts such as has rarely been amassed before. Even if his theories should in the course of time be merged in some wider and more complete generalisation, his merit as an acute and patient investigator of facts can never be disputed. If any man wishes to become a naturalist, we would say to him—"In addition to the actual study of things, read Darwin; read him pen in hand, not necessarily with unhesitating belief, but critically, or if you will even sceptically, so long as your scepticism is candid and scientific. If you do not find everywhere suggestions how, where, and what to observe, you have mistaken your vocation, and will never make a worthy student of animal or vegetable life.

For the benefit of those who possess the first edition of this book, a table of additions and corrections is appended.

Physical Geography, or the Terraqueous Globe and its Phenomena. By W. DESBOROUGH COOLEY. London: Dulau and Co.

THIS book begins with a preface in which the nature and scope of "Physical Geography" are discussed. On this subject it would appear that some diversity of opinion, not to say confusion, prevails. The ordinary distinction between Physical and Political Geography is characterised as "a feeble and useless attempt to distinguish between a description of the earth and a description of the countries and kingdoms of the earth, the natural philosophy involved with geographical considerations being in the meantime forgotten."

The most important and interesting portion of the work is the last chapter, in which the author, though not hostile to the nebular hypothesis of Laplace, combats the ordinarily received notion that the earth was at one time a liquid globe. He declares that "in order that it should take a spheroidal figure it was not necessary that it should be fluid." Of an original fused condition there remains on the earth no trace. "Since aërolites," he asks, "are continually falling on the earth, why might they not have fallen in the first instance? Why may not the earth, or at least the exterior portion of it, have been formed of mineral particles solidified before they met to form a globe?"

He thinks it "natural to suppose" that the earth was, in the beginning, a perfect spheroid, as symmetrical as if it had been turned in a lathe. He complains that "the most remarkable and eventful crisis in the history of our globe is passed over in silence by the geologist, who begins his history of the earth's formation with uniformity and the established routine of Nature; that is to say, he supposes equilibrium to be established, the conflict of natural forces being at an end and the earth's system complete, and yet affects to start from the beginning."

The alternate rising and sinking of the land, generally admitted by geologists, he denies, or seeks to ascribe it to fluctuations in the level of the sea. That the testimony of the coral islands must not be neglected he admits. This testimony, we suspect, he will have great difficulty in reconciling with his views.

In a section on the effects of lightning we are told that, "at Graaff Reynett, in the eastern division of the Cape Colony, the Court-house was some years ago struck by lightning; and the bell-wire running through the building, and altogether about 80 feet in length, fell to the ground, cut into small pieces of equal length (about three-quarters of an inch)." A precisely similar occurrence has since been witnessed in a workhouse in the North of England. As further freaks of lightning we find it mentioned that 2000 goats, driven for shelter into a cave in Abyssinia, were all killed by a single stroke of lightning. It is also stated that some years ago a French regiment, on the march near Lyons, was completely prostrated by lightning, the men being all thrown down in succession (?), but none killed. These facts will furnish electricians with matter for study. The meteors known as "fire-balls" he considers eminently unaccountable. "Their frequent occurrence and dangerous character are well attested; yet nothing is known with certainty of their nature." That they are rightly to be classed with electricity he doubts. "Compact electricity, hovering slowly in the air, apparently without either attraction or repulsion, rolling on the ground, and then suddenly exploding like a bombshell, is a compound of contradictions hardly conceivable." "It is for chemists to decide," he adds, "whether gaseous matters generating electricity may not by some means be concentrated in the atmosphere, and explode by mixture with oxygen gas at a certain stage of their combustion." Globes of a gaseous mixture rolling on the ground, or slowly hovering in the air and behaving like potassium when thrown upon water, are also not very readily conceivable.

The author's explanation of "glacial epochs" is to some extent that of Mr. James Croll, whose chronology of the cold periods he however rejects, though praising him for "having had the courage to condemn Sir Charles Lyell's doctrine of uniformity, generally received by geologists."

The following speculation is at any rate curious:—"A diminution of the weight of the atmosphere may be justly inferred from the fact that extinct species of animals, as seen in fossil remains, appear to have been collectively created on a larger scale than the corresponding species at present existing. Heavy animals were relatively more numerous, and weight rather than agility characterised the figures of all." Now, that certain extinct animals must have been larger than any now existing is admitted; but we are unable to discover any regular and serial decrease from the earliest epochs downwards. "Under a very heavy atmosphere," says Mr. Cooley, "the elephant would feel relieved of much of its weight, and become a comparatively active animal." Unfortunately the elephant and the rhinoceros, clumsy as they look, are decidedly active animals.

As a theorist we do not think the author happy; but he has a remarkable facility for collecting anomalies and pointing out unsolved problems. Hence this work may be pronounced exceedingly suggestive, and must be recommended to the careful study of geologists.

Practical Plane Geometry. By E. S. BURCHETT. London and Glasgow: W. Collins, Sons, and Co.

THIS work is in its objects and nature totally different from "Euclid's Elements." It has been compiled, as the author informs us, "on account of a strongly-felt want of a more complete text-book upon the subject." Its aim is practical, not theoretical. Hence, beyond the introduction, it consists of problems and of applied geometry, including such subjects as the repetition of geometric figures to fill plane surfaces, the lines of arches, the curves of mouldings, Gothic tracery, and the construction of scales. An Appendix treats of the elements of orthographical projection.

We consider the work likely to prove of no small value to architects, builders, and to designers of ornamental work in metals, glass, and other materials.

Annual Report of the Board of Regents of the Smithsonian Institution for the Year 1874. Washington: Government Printing Office.

THIS yearly issue contains the Report of the Secretary, Prof. Henry, including the financial statement; list of publications issued and in the press; account of researches conducted in meteorology, astronomy, physics, natural history, and ethnology; account of international exchanges, &c. The National Museum of the United States appears to have received many and valuable additions from almost all parts of the world.

The accompanying literary matter consists of the Eulogy of Laplace, by Arago, as delivered before the French Academy; the Eulogy on Quetelet, by Ed. Mailly; and of A. A. de la Rive, by M. Dumas. It may be interesting to our readers to learn that, in addition to his well-known eminence as a mathematician and statistician, Quetelet possessed considerable merit as a poet—a somewhat rare combination of talents. There are also papers on "Tides and Tidal Action in Harbours," by Prof. J. E. Hilgard; "Observations on the Electricity of the Atmosphere and the Aurora," by Prof. Lemström; on a "Dominant Language for Science," by Prof. de la Carpolle; on "Underground Temperature," by Messrs. Schott and Everett; "Earthquakes in North Carolina," by Prof. Warren du Pre; "Transactions of the Society of Physics and Natural History of Geneva, June, 1872, to June, 1873;" a "Report on Warming and Ventilation," by A. Morin; and a number of brief ethnological notices.

Some Account, Critical, Descriptive, and Historical, of Zapus Hudsonius; *and on the Breeding-Habits, Nest, and Eggs of the White-tailed Ptarmigan,* Lagopus leucurus. By Dr. ELLIOTT COUES, U.S.A. Washington: Government Printing Office.

A COUPLE of useful monographs, which the binder has unfortunately blended together in a curiously perplexing manner. It is singular that the *Zapus Hudsonius* has been honoured with no fewer than forty-four synonyms, and has been referred to the genera *Dipus*, *Gerbillus*, *Meriones*, *Jaculus*, and *Mus*.

An Account of the Various Publications relating to the Travels of Lewis and Clarke, with a Commentary on the Zoological Results of their Expedition. By Dr. ELLIOTT COUES, U.S.A. Washington: Government Printing Office.

THIS pamphlet, extracted from the "Bulletin of the Geological and Geographical Survey of the United States," consists of two portions, the bibliographical and the zoological. The author, having frequent occasion to consult the work for facts bearing upon the zoology of Western North America, found quotation impossible without explicit reference to some especial edition. Neither of these early explorers became the actual author of an account of their joint expedition and its results; but whilst their notes were being edited two separate and incomplete versions fell into the hands of publishers, and have become the groundwork of a number of apocryphal editions.

The zoological portion consists of a catalogue of the mammalia and birds discovered or observed by Lewis and Clarke, with references for each to the respective editions.

The Cholera Epidemic of 1873 *in the United States.* By J. M. Woodworth, M.D. Washington: Government Printing Office.

Under this title we have a volume extending to upwards of a thousand pages, which, though ostensibly designed merely as an official report on the last epidemic of cholera in the United States, presents a great amount of valuable information on the sources, propagation, and treatment of this dreaded pestilence. The author does not accept the theory that cholera is transmitted in the atmosphere, or depends upon occult cosmic influences. From the facts which have come under his observation he deduces the following propositions:—

"I. Malignant cholera is caused by the access of a specific organic poison to the alimentary canal, which poison is developed spontaneously only in certain parts of India.

"II. This poison is contained primarily, so far as the world outside of Hindostan is concerned, in the ejections—vomit, stools, and urine—of a person already infected with the disease.

"III. To set up anew the action of the poison, a certain period of incubation, with the presence of alkaline moisture, is required, which period is completed within one to three days; a temperature favouring decomposition and moisture or fluid of decided alkaline reaction hastening the process, the reverse retarding.

"IV. The period of morbific activity of the poison is characterised by the presence of bacteria, which appear at the end of the period of incubation, and disappear at the end of the period of morbific activity; that is to say, a cholera ejection or material containing such is harmless both before the appearance and after the disappearance of bacteria, but is actively poisonous during their presence.

"*Note.*—It is not meant by this that the bacteria so found are the cholera-poison, since they differ in no appreciable manner from bacteria found in a variety of other fluids. Indeed Lebert hints that the bacteria may even be the destroyers of the poison."

In another passage, however, we are told that Dr. Nedsvetzky, of Yaroslav, near Moscow, "has apparently discovered the cholera bacterium, which is developed in enormous quantities in the discharges. He found that quinine, camphor, carbolic acid, tar, calomel, and chloral had no effect upon them; that opium, nux vomica, and chloroform killed them slowly; while tannin, sulphate of iron, chlorine water, and dilute sulphuric, nitric, and muriatic acids killed them rapidly." He suggests the latter six remedies as the most efficient against cholera.

The author also considers that the cholera-poison may be destroyed by acids, and recommends them—especially dilute sulphuric acid—as prophylactics. The value of "sulphuric acid lemonade" is indeed fully shown by the account given by Dr. Curtin of his experience at the Philadelphia Hospital in 1866. During the time the acid was used only one new case occurred. "This was a poor lunatic, who, upon tasting it, spat it out, and surprised me very much by saying with great vehemence—'Docther, you call this limonade, but ye can't desave me; it's nothing but ile of vitriol.'" This woman took the disease, and died. Districts where the air is saturated with sulphurous fumes have been remarkably free from cholera, and persons whose employment exposes them to similar vapours have enjoyed a striking immunity. We may here remark that not a few independent observers have formed a very high opinion of the value of sulphuric lemonade as a beverage in hot and malarious districts, and consider it decidedly superior to the vegetable acids.

Unlike many diseases, cholera shows little marked preference for age, sex, race, or condition of life. The negro race seem to suffer more than Europeans. "The disease was most malignant among the lower orders of each community, but the better classes were by no means exempt."

The author's strictures on the sanitary condition of many cities in different parts of the world, though severe, are only too well founded. Much as still remains to be done before the sanitary condition of England is satisfactory, it is some consolation to know that we are in advance of our Continental neighbours.

An interesting and valuable feature in this work is the bibliography of cholera, extending to over three hundred pages.

Report of the United States Geological Survey of the Territories. By F. V. Hayden, United States Geologist-in-Charge. Vol. II. Washington: Government Printing Office.

This volume, containing an account of the Vertebrata of the Cretaceous Formations of the West, is a document absolutely priceless to the palæontologist, and reflects the highest credit on its authors, and not less on the Government which so liberally places it in the hands of learned societies throughout the world. In addition to illustrations inserted in the text, there are fifty-three large lithographed plates, most carefully executed and well explained. Such work as this volume represents is absolutely necessary for the progress both of geology and zoology. At the same time it is evidently beyond the means of private individuals. We can only therefore wish that the noble example set by the Government of the United States may be followed elsewhere. Incidentally we may notice that the measurements of the various fossil remains investigated are given on the metric system.

The authors infer from their researches that the distinct faunal areas which the earth now presents—the more prominent among which are those respectively of Australia, of South America, and of the temperate regions of the northern hemisphere—have always prevailed, so far, at least, as the extinct Mammalia are concerned. The writers ask—"Was the succession of interruptions of life universal over the globe, and do these trenchant lines justify the old assumption of repeated destructions and recreations of animal life? The former question has already been answered in the negative by the explanation of the characters of the existing faunæ of the southern hemisphere, where ancient types still remain in considerable numbers. Moreover, some of the later periods, both of North America and Europe, are characterised by a large predominance of forms of the corresponding southern continent. It is, indeed, evident that migration from the one continent to the other has taken place, and is amply sufficient to account for the abrupt changes in the life of each without necessitating the intervention of creative acts. If glacial periods be dependent on cosmic movements, the increased obliquity of the earth's axis to the sun at periods 25,000 years apart would cause a corresponding alternation of cold periods in the opposite hemispheres. This is well known as a most potent cause of migration and extinction, and the known relations of the faunæ would thus result from a greater or less alternate invasion of one hemisphere by the life of the other."

The distinct terrestrial faunæ within these great periods are referred to the "alternate presence and absence of water-areas adapted for the preservation of animal remains,"—a variation due to the slow vertical oscillations of the earth's crust.

Hence it appears that the authors do not find any evidence favourable to the vicious principle of *omnia per saltum*,—a reactionary doctrine whose rehabilitation is in some quarters so earnestly attempted.

Tables, Nautical and Mathematical, for the Use of Students, Seamen, Mathematicians, &c. Arranged, Corrected, and some Re-calculated. By HENRY EVERS, LL.D. London and Glasgow: W. Collins and Sons.

THE author remarks, in his preface, that his object has been "to arrange a new set of handy, clear, and correct mathematical and nautical tables, for the use of the student and expert practitioner in mathematics, navigation, nautical astronomy, steam, surveying, &c." This task appears to have been satisfactorily fulfilled: the tables are well selected and clearly printed.

Geology of Otago. By F. W. HUTTON and G. H. F. ULRICH. (Printed by order of the Provincial Council of Otago.) Dunedin: Mills, Dick, and Co.

IT is pleasant to find that in the "Britain of the South" Science is not neglected. The volume before us gives an account of the physical geography, the geology, descriptive, historical, and economic, of the province of Otago. The mineral wealth of the district appears to be considerable. Antimony occurs in considerable quantity, as stibnite, at the Arrow River, Carrick Ranges, Waipori, and other places. Tungstate of lime occurs plentifully in various parts. Alum shales are found at Waikouaiti, but their practical value is doubtful. Retinite is so plentiful in the lignites that it is collected for the manufacture of varnish. There is a lode of copper at Moke Creek, Lake Wakatipu, but no other has been discovered. Hæmatite containing 94 to 96 per cent of oxide of iron occurs in a lode 6 feet thick at Moori Point, on the Shotover, and at Port Molyneux, and good clay ironstone exists at Tokomairiro. As in all these places lime and coal can be obtained at no great distance, iron-works will doubtless spring up. Titaniferous iron-sand is found in quantity at Port William, in Stewart Island. Iron pyrites, an important element in the industrial development of a country, are said to be common, but we can find no mention of the percentage of sulphur, or of the presence or absence of arsenic. Silver, platinum, cinnabar, and native mercury are mentioned in the list of minerals without full information as to their quantity. Wavellite occurs, but no mineral phosphate of lime appears to have been discovered. The coal-fields are important—that of Tokomairiro is estimated to contain 768,000,000 tons of available coal, after making the usual deduction of one-third for waste, &c. Thus New Zealand can enjoy, on the one hand, the advantages of manufactures, and on the other the nuisances of smoke, of colliers, and perhaps at some future date of a "coal-ring."

Gold is, however, at present the mineral commodity most sought for in Otago. The following method is given for an approximate determination of gold in pyrites:—"Weigh a good average sample of the dry ore—say about 2 lbs.—and roast it till perfectly *sweet* (on a shovel over the fire will do), *i.e.*, till no more smell of sulphurous or arsenious acid is perceived on stirring. Place the roasted mass in an iron mortar, mix it with so much water that it just forms a *very stiff* paste, and add a table-spoonful of quicksilver. Rub with the pestle till all the quicksilver has disappeared. A second similar amount of quicksilver is then worked through in the same way, and then hot water, a little soda, and about five or six table-spoonfuls of mercury are added, and the mass gently stirred for some time, to allow the finer particles of mercury to settle down and unite with the large lot at the bottom just put in. Now follows the careful washing away of the red oxide of iron slime, in an enamelled iron dish, and ultimately the retorting—at not too strong heat—of the whole of the mercury collected. From the weight of the gold left behind the gold per ton can be easily calculated. The experiment closely imitates the process adopted on the large scale, and, if carefully executed, gives within 80 to over 90 per cent of the fire assay."

In an Appendix there is an account—accompanied with diagrams, drawn to scale—of the German metallurgical furnace for burning brown coal, known as the "Treppen-rost."

In speaking of the soils of the province, which are characterised as being above the average in quality, and which if carefully managed will prove a source of wealth after the gold-fields are worked out, the authors make a very significant remark:—"The gold-miners are in league with the rivers, and we may feel sure that before many years are passed considerable quantities of agricultural land will be either washed away or covered with 'tailings.'" This is one of the many cases, not dreamt of in the philosophy of the Manchester school, which prove that individual covetousness—or, if you will, individual industry—does not, when left to its own guidance, invariably promote the general good.

Turning from economic to historical geology, we find it mentioned that in 1874 Mr. W. L. Travers brought forward conclusive proof that New Zealand has never been covered by an ice-sheet, or, in other words, has never experienced a glacial epoch. Mr. Hutton, from his own observations, also, maintains that neither in the pliocene nor in the pleistocene times has New Zealand experienced a colder climate than at present. This conclusion, if substantiated, is of great importance.

The fauna of the province is remarkable for its poverty. Sixty-one species of land-birds in a country not over-peopled, and infested neither with Whitechapel bird-catchers nor with French sportsmen, is a very meagre list. Of these, six species belong to the parrot group. The insects, curiously enough, are not mentioned : this is a very serious omission, not merely from the point of view of the scientific naturalist, but from that also of the farmer. The flora of the province has also been overlooked. Wheat is extensively grown in the lake-districts at from 1000 to 2000 feet above the sea-level, but the remark is added that this is not to be taken as the limit of its successful cultivation : this indicates an agricultural climate very much superior to that of England. The forest-line is given at 3400 and the snow-line at 7500 to 8000 feet. We find, also, some interesting remarks on the character of the scenery, which is declared to be eminently beautiful. The mountains, which reach an altitude of nearly 10,000 feet, are exceedingly bold in their outline. "The lakes present scenery unsurpassed probably in the world, for, unlike the Swiss lakes, they do not lie outside the principal mountain masses, but wind close round their feet." Waterfalls are few and small.

The work is illustrated with several plates, showing sections, &c., and with a geological map on the scale of 24 miles to the inch.

Practical Physiology. By Edwin Lankester, M.D., F.R.S., Sixth Edition. London : Hardwicke and Bogue.

This work was originally entitled "School Manual of Health," and was intended to serve as a reading-book in primary educational establishments. The author, however, finding that it was principally used "as a text-book in classes formed for the study of physiology in its relations to health and life," has changed its title, and added a large number of illustrations, a series of questions, and a glossary. The result is a book containing an abundance of sound and valuable practical information, mixed, however, with speculative passages of an occasionally questionable nature. In the Introduction the author enters upon that vexed question, the scope and the character of mental training suitable for various classes of the community. Here we are struck with the following dictum :—"I wish, however, to state my conviction as a physiologist that there is no anatomical distinction between the brains of rich and poor people !" We have rarely seen a truism—admitted everywhere, save, perhaps, in the Manchester Chamber of Commerce—enunciated with greater solemnity. But this undoubted truth has, after all, little direct bearing on the subject. The question is not to what degree of education persons of such and such a class are entitled, but what is practically attainable. So long as the majority of youths have to enter upon their business at an age below, say, eighteen, so long must a broad and thorough mental culture be not the rule, but the exception. Seldom has a deadlier blow been struck at the well-being of our race—physical, intellectual, and moral—than when young children were first led or driven into an industrial career. One no less deadly is aimed by those who, under what pretext soever, aim at transferring women from the household to the workshop and the office.

Dr. Lankester's remarks on the absence of physiological knowledge among statesmen, municipal bodies, and literary men are excellent. "To those," he writes, "whose professional avocations lead them to speak on physiological subjects, it is often a source of great annoyance to find that their remarks have been thoroughly misunderstood by the ignorance of physiology among those whose duty it is to supply information through the press." But this complaint admits of generalisation. The ignorance of physiology is merely part and parcel of that want of scientific culture of which we daily meet with strange instances among the "educated and respectable classes." Not long ago, in an eminent daily paper, we came upon a lengthy notice of an astronomical work, in which the reviewer gravely stated that all gases would explode at temperatures far below redness, the product of the explosion being "a vacuum, with a few grains of dust." This reminded us of a fellow-student of ours, long ago, who on being required to analyse a mineral gave in a certain percentage as "dirt."

But ignorance is far from being the only reason why town-councils and vestries meet sanitary regulations with cold support, if not even with passive opposition. Disease and dirt are vested interests, and are generally influentially represented in town-halls and board-rooms.

Dr. Lankester evidently holds that a more generally diffused acquaintance with physiology would be a great boon to the community. He says—"The sum of human suffering that might be prevented and the amount of wealth that might be saved by a knowledge of the laws of disease is incalculable." And again —"As long as this subject is thus slighted and neglected in our plans and systems of education, so long will the miseries that arise from premature disease and death occur, and so long will poverty and physical debility obstruct the progress of mankind in the path to wealth and happiness." Now no one can deny that many persons are reduced to want, and may even become burdens to the public, in consequence of disease. It must further be conceded that if a child dies before arriving at the age when productive labour becomes possible, all that has been expended on its nurture and education is wasted. But, on the other hand, if every person born were to survive to the age of a century and upwards, as in the model city Hygeia, or even to the traditional three score years and ten, unless the means of subsistence could be increased in a corresponding proportion the struggle for existence would be fearfully intensified, and destitution would prevail to an extent which is now utterly inconceivable. Thus, in their efforts to remove one evil, philanthropists, if they succeed at all, are apt—like the village tinker—to create a greater.

Turning from this interesting and suggestive Introduction to the body of the work:—

The remarks on drinking-water call for notice. "Hardness" may be in part caused by salts of magnesia, as well as lime, and in the former case relatively small quantities are objectionable. We should not place much confidence in the benefits to be obtained by boiling water containing organic impurities. Certain volatile matters would doubtless be driven off, and "germs," if present, might be destroyed, but there would still be an offensive and dangerous residue. Nor can we approve of the use of condemned waters for washing. A test for water, still simpler than the addition of Condy's fluid, is to cork up a quantity of it in a clean bottle, and leave it for a few hours in a rather warm place. If, on uncorking the bottle, a bad smell is perceived the water should be rejected.

Dr. Lankester very judiciously condemns cold meat, that haunting sin of the English *cuisine*. He says—"When cold food is taken it reduces the temperature of the stomach, and both the nerves and vessels of the stomach are taxed in order to bring the temperature of the food thus taken up to that of the human body. It is only in very hot weather or in tropical climates that food can be taken with advantage when cold." We fear, however, that this authoritative condemnation of cold mutton will not meet with the approbation of his lady readers.

On the subject of clothing Dr. Lankester gives very good advice. He declares that "black and dark substances, whilst they absorb heat best, also radiate or give it off quickest, so that it is really better to wear light-coloured clothes both in summer and winter. The true reason why the civilised inhabitants of Europe and America dress in dark-coloured clothes both in summer and winter is economy. It is a question of *soap* and *washing*, and not of the comfort or use of the dress." Jean Paul Richter, if we remember rightly, puts this point more tersely. "The ancient Spartans," he says, "wore red to hide blood; the modern Italians wear black to hide fleas."

The author seems disposed to uphold the old notion of a contrast, or difference of kind, rather than of degree, between man and the rest of the animal world. For this purpose he sometimes goes out of his way. Thus in one place he takes occasion to observe that "the human skeleton has two hands and two feet, and is not four-handed, as in the highest monkeys." But according to the best and most recent authorities the hinder limbs of the highest apes terminate in true feet, and, in accordance with this conclusion, theorists most eager to uphold the "great gulf" between man and beast have abandoned this ground. We regret to see, in a work which has such just claims to a wide circulation as the present, a classification of the animal kingdom in which the Cuvierian order of "Bimana" is still recognised, whilst the following order, "Quadrumana," is made to embrace forms differing from each other structurally much more widely than do some of them from man. Were these passages modified in accordance with the teachings of philosophic zoology, and were certain doubtful passages in the Introduction withdrawn, we should think ourselves justified in speaking of this book in terms of almost unqualified approbation.

Handbook of Astronomy. By Dionysius Lardner. Fourth Edition, Revised and Edited by E. Dunkin, F.R.A.S., of the Royal Observatory, Greenwich, and Secretary of the Royal Astronomical Society. London: Lockwood and Co.

We once heard tell of an amateur gas-manager in a northern town who could not make good gas, but who accomplished a feat far more difficult. He prevailed upon his townsmen to burn bad gas, to pay for it at a high price, and to believe most devoutly in its excellence. Something similar occurs in the scientific world. We meet from time to time with men who do not shine in original research. They neither reveal to us new phenomena, nor do they make any important step in theory; but they contrive to outshine and almost eclipse the modest scientific worker. They become members—and leading members—of learned societies. Professorial chairs, commissionerships, decorations fall to their lot, and it is generally not till their death that the plain question "But what has he really done?" is frankly asked, and receives no answer. Of such men the Rev. Dionysius Lardner was at one time the type. He was LL.D, F.R.S. L. and E., M.R.I.A., F.R.A.S., F.L.S., F.Z.S., Hon. F.C.P.S., not to speak of minor honours. He was Professor of Natural Philosophy and Astronomy at University College, but in popular belief he was supposed to be a transcendant authority in every department of Science. True, when he went to towns in the North and lectured to mechanics on the steam-engine, some of his audience were rude enough to remark that if they knew no more about the steam-engine than did the *petit-maitre* on the platform they would soon have to "shut up shop." But these critical utterances were lost in the general applause, and it was not till the Professor's moral fall that his claims as a man of science were formally re-considered.

Among the many works which he wrote or edited, "with the assistance of men eminent in certain departments," was the treatise before us.

It must not be inferred from these remarks that we are dissatisfied with its character. On its first appearance it came to be regarded as an ably compiled summary of the astronomical knowledge of the day, drawn up in "ordinary and popular language," and divested, as far as the subject admits, of puzzling technicalities, and especially of that parade of mathematics which, above all things, deters the general reader. The present editor, working on the same general lines, has embodied in the book the results of more recent research. It is no empty boast when he declares in the Preface that "to the student of the higher or mathematical branches of astronomy this work, however, will also be found interesting and instructive, as he will find information of the most valuable kind in it, for much of which he may look in vain in works of higher pretensions." Beginning with an account of astronomical methods of investigation and means of observation, the author passes to a description of astronomical instruments and their mode of use. It will be interesting for the general reader to compare the gigantic and exquisitely finished instruments described and figured in this section with the telescopes once used by the fathers of astronomical science, now on view in the Loan Collection of Scientific Apparatus at South Kensington.

The next chapters treat of the general rotundity and dimensions of the earth, of its spheroidal form, mass, and density; of the apparent form and motion of the firmament; of the earth's diurnal and annual rotation; of atmospheric refraction and parallax; of precession and mutation. The author next gives a description of the moon, noticing her effect upon the tides and trade-winds; of the sun, and of the solar system in general. Next follows an account of the planets classified under three groups—the terrestrial, the planetoid, and the major or exterior. Eclipses, transits, and occultations are next explained. Thence we are led to a survey of the comets, and of the so-called fixed stars,—a department of astronomy which has been wonderfully enriched during the third quarter of the present century. The work is well illustrated, and is provided with a good index.

We can do no other than pronounce this work a most valuable manual of astronomy, and we strongly recommend it to all who wish to acquire a general—but at the same time correct—acquaintance with this sublime science.

A Critical Examination of some of the Principal Arguments for and against Darwinism. By James Maclaren, Barrister-at-Law. London: E. Bumpus.

It is a trite saying that there are three tasks which every man thinks it within his power to accomplish—to drive a gig, to manage a farm, and to edit a newspaper. To these the experience of the last few years warrants us in adding a fourth. Every man of culture—no matter how little qualified by especial training or previous study—deems himself entitled to pass an authoritative judgment on the most abstruse questions in organic science. Lawyers, divines, mathematicians, literary men, financiers who have never devoted an hour to the serious study of zoology or botany,—who have never observed a novel fact or verified an old one, who have never even determined a species, and who would be utterly at sea were they to make the attempt,—consider themselves competent to discuss the origin of species, not merely in private, but for the edification and guidance of the public. This is not the case in other departments of knowledge. Some years ago there arose a dispute among physicists concerning two rival views on the nature of light,—the undulatory and the emission hypothesis. Considerable animosity prevailed between the combatants, and some of the language used was decidedly unparliamentary; yet the outside public wisely held aloof, and left the matter to be decided by experts,—men versed in physics and mathematics, and capable of rightly appreciating the evidence adduced on either side.

More recently we have witnessed a discussion in chemistry between the respective partizans of the new and of the old notation. The controversy opened out for many men a royal road to eminence, by giving them an opportunity for writing books for which no *raison d'etre* would otherwise have existed; but the public and the general press did not interfere on the one side or the other. Why it should have adopted so different a course with respect to the origin of species is not clear; it cannot be because the subject is more within the grasp of an unprepared mind. We will venture to declare that zoology and botany, if taken up as sciences, are far more complicated and difficult than chemistry or physics; it may be because the origin of species, that of man included, is a more interesting subject than a theory of light: this, however, is the very reason why it should have been let alone. It is only too interesting, and excites too much passion and prejudice to be dealt with by any but specially disciplined minds.

Turning from the actual to the hypothetical, let us suppose—a thing not entirely inconceivable—that a difference of opinion were to prevail among the legal profession upon some important topic, and that an outsider—a botanist, or a geologist, or an electrician, ignorant of law and relying merely upon his general mental cultivation—should write a book, formally summing up the arguments on either side, and pronouncing a decision, would not all the Inns of Court ring with contemptuous and most justifiable laughter? But where is the essential difference between such a supposed case and the one before us? We know that exception will be taken to this view. Our author remarks that the evidence for or against Darwinism ought to be intelligible to every educated man. We must confess that we see no such obligation. The evidence upon which a scientific theory rests should be intelligible to a man who has made the science in question his study, just as the specification of a patent must be intelligible to men accustomed to the particular trade or manufacture with which such patent is concerned; but to demand more is unreasonable. It has also been urged that the procedures of logic, like the rules of arithmetic, are equally applicable to all subjects irrespective of their peculiar nature, and that a lawyer accustomed to take no point for granted, to require a reason for everything, and to scrutinise chains of argument, is the very man to deal profitably with such a question as Darwinism.

All these pleas involve half-truths, or, in other words, errors of the most dangerous class. The accountant's sum-total, if obtained according to arithmetical rule, is doubtless true as far as the figures on his paper are concerned; but before we can grant their value we must ascertain whether those figures relate to realities or to mere assumptions. The logician's conclusion, rightly drawn from his premises, will be formally true; but before we can accept it as of objective value we must verify his premises,—and this is precisely what no outsider can do.

We may further submit that there is no necessity for a man to form an opinion at all concerning the origin of species. If he has not the time, the opportunity, and the will to make the question the subject of his especial studies, and if he has little or no previous knowledge bearing on the point, his legitimate course is to suspend judgment. Least of all should he come forward as a teacher before he has been a learner.

We may call the attention of the lawyer who thinks himself qualified to discuss this question to an illustration taken from his own profession. What would be thought of a judge who should pronounce an award after having listened to witnesses speaking a foreign tongue, and whose testimony was interpreted, if at all, only by partisans? We believe we could lay before Mr. Maclaren evidence on the origin of species concerning which he would be unable to tell whether it was favourable or adverse to the views of Messrs. Darwin and Wallace. If we translated it for him into words, he would still have to decide in how far our interpretation was fair or in how far vitiated by party spirit. Nay, even the evidence which is given in books—no matter how ably, clearly, and candidly written—conveys to the working naturalist a very different meaning from what it does to the outsider. The latter has to deal, as it were, not with the direct light, but with that which has passed through a refracting medium.

We are highly gratified with the increased attention paid on all sides to Natural History, due, in no small degree, to the impulse given by Mr. Darwin and his immediate followers; but we would wish all neophytes to master the alphabet of the science before they proceed to grapple with its greatest difficulties. We must therefore earnestly deprecate the appearance of works like the one before us, believing that they retard instead of promote the definite solution of the question they attempt to discuss.

We must go still further: we utterly repudiate the claims of metaphysicians and philologians, *as such*, to be heard on the origin of species. Prof. Max Müller has possibly traced human language back further than any other investigator, and has made words tell us historial secrets almost as interesting as those which the geologist elicits from the examination of fossils; but words can evidently bear no witness as to a state of things antecedent to their origin. When Prof. Müller declares on the Darwinian theory he is very much in the position of a topographer who, having traced every affluent of the Thames to its source, and, if you will, gauged its flow and analysed its water, should therefore think himself competent to decide on the origin of the clouds and mists by which those affluents were originally fed.

Let us now examine in what manner the author has executed his task. The first point that strikes us is that he does not distinguish with sufficient clearness between *Evolutionism*—the doctrine of a progressive mutation of species—and *Darwinism*, —the explanation of such changes by the hypothesis of Natural and Sexual Selection. The former, we need scarcely remind our readers, may be and is admitted by those who cannot accept the explanation offered by Mr. Darwin.

We next notice that Mr. Maclaren places the views of mere literary men of the world, such as the late Bishop Wilberforce in the same rank with those of original observers, such as Messrs. Darwin and Wallace on the one hand and Mr. Mivart on the other. Are we to infer that he would, as a lawyer, accept hearsay evidence as at all approaching in weight to the testimony of an eye-witness? The criticisms of the Bishop, as taken from his article in the "Quarterly Review" may be interesting as a specimen of the manner in which unscientific minds are apt to deal with scientific questions, but as a contribution to biology they merely provoke a smile. Mr. Maclaren re-quotes from Dr. Wilberforce the passage in which Prof. Owen urges —"How unerringly and plainly the extremest varieties of the dog kind recognise their own specific relationship; how differently does the giant Newfoundland behave towards the dwarf pug, on a casual *rencontre*, from the way in which either of them would treat a jackal, a wolf, or a fox." Yet we have the strongest possible evidence that the domestic dog, *Canis familiaris*, is an artificial product formed by the intermixture of different wild species. Even now the breed is known to be fruitfully and purposely crossed with the wolf and the fox, whilst no one has been able to point out the dog as existing anywhere in a state of original wildness. There is generally more or less manifestation of hostility when a tame animal meets a wild member of its own species. Need we then wonder if a dog meeting a fox or jackal should show but small tokens of friendship? It is commonly supposed that the entire human race belongs to one and the same species, yet the mutual repulsion between certain of the different strains of man is as well-pronounced as that between the dog and the fox.

We may next notice certain passages extracted from a paper in the ninety-second number of the "North British Review," in which the doctrine of Natural Selection is attacked from what may be called a mathematical point of view. We quote the passage:—"The advantage gained by one individual who has been favourably modified, is utterly overbalanced by numerical inferiority. A million creatures are born, ten thousand survive to produce offspring; one of the million (from a favourable variation) has twice as good a chance as any other of surviving, but the chances are fifty to one against the gifted individual being one of the hundred survivors. No doubt the chances are twice as great against any other individual, but this does not prevent them from being enormously in favour of some average individual. All that can be said is that the favoured 'sport' would be preserved once in fifty times. In the second place, let us consider what would be its influence on the main stock when preserved. It will breed and have a progeny of, say one hundred; now this progeny will be, on the whole, intermediate between the average individual and the sport. The odds in favour of one of this generation will be, say, one-and-a-half to one as compared with the average individual. The odds in their favour will therefore be less than that of their parents, but owing to their greater number, the chances are that about one-and-a-half of them would survive. Unless these breed together, a most improbable event, their progeny would again approach the average individual, and so on until all trace of the original improvement disappeared."

"Suppose a white man to have been wrecked on an island inhabited by negroes, and to have established himself in friendly relations with a powerful tribe whose customs he has learnt; grant him every advantage which we can conceive a white can have over a native, yet it does not follow that after an unlimited number of generations the inhabitants of the island will be white. Our shipwrecked hero might become king, he might kill a great many blacks in the struggle for existence, he could have a great many wives and children. In the first generation there will be dozens of young mulattos much superior in average intelligence to the negroes. We might expect the throne to be occupied for some generations by a more or less yellow king, but can anyone believe that the whole island can gradually acquire a black or even a yellow population?"

This extract is a very good instance of the quietly adroit manner in which mathematicians are apt to beg the question, and we regret to see that Mr. Maclaren has but a very remote suspicion of the fallacies involved in the argument and the illustration. It is assumed that the outward circumstances remain the same; that young animals are exactly intermediate between their parents, and, above all, that the advantage of the improved "sport" over the average individual is as two to one. Now let us, in turn, suppose that an animal is produced swifter than the rest of its species; that an enemy makes its appearance swifter than the average individual, but slower than the "sport." The chance of the latter surviving and leaving progeny would then not be double that of the ordinary individual, but greater beyond all comparison. Its mate would probably not be one of the slowest of the species, since all such would stand the greatest chance of being devoured by the enemy. Amongst its offspring, judging from facts daily observed, there would be some as swift as itself, and possibly even swifter, and these would become the progenitors of the new race. Or let us take the "North British Reviewer's" illustration of a white man shipwrecked upon an island inhabited by blacks, and there intermarrying with a native woman. Among his children, despite the doctrine of averages which bids a poor wretch shivering over an empty fire-grate on a cold winter's night to feel comfort in the thoughts of a great conflagration at the other end of the street—some will be found very closely resembling their father. If now a new disease fatal to blacks and comparatively harmless to whites, like the measles at Fiji, appears and becomes endemic in the island, the children of "our shipwrecked hero" would escape its ravages just in proportion as they inherited their father's constitution, and the population of the island might in such a case become permanently a light yellow.

On the fertility of hybrids Mr. Maclaren remarks:—"Both Lamarck and our author are obliged to allow the general existence of a great degree of sterility among hybrids, and though they may give some instances of partial fertility, we are strongly reminded of the old canon, exception proves the rule." This "old canon" is in the eyes of men of science about as acceptable as the saying of Sir Thomas Browne—"I believe, because it is impossible." Suppose it were found that the law of definite proportions did not extend to all the elementary bodies, would any chemist contend that such an exception "proved the rule?" So far from it, he would cease to regard the law above-mentioned as a "rule" at all, and consider it merely as a provisional and imperfect generalisation. Leaving on one side the case of the *leporides*, the cross between the hare and the rabbit (whose existence Mr. Maclaren does not think proper to admit), there are cases quite sufficient of fertile hybrids amongst the respective groups of finches, of grouse, and of ducks. So that, though as Prof. Oscar Schmidt happily says, "by ill-luck" the most ancient and common case of hybridisation—that of the mule and the hinny—supports the common doctrine, all that we can truthfully say is that some hybrids are fertile, whilst others are not, which is simply no rule at all. This subject is one which stands in need of extended and careful experimental research. Only we fear that some one of the "societies" which have taken the morals of the English public under their especial care will some day suddenly awake to the conclusion that such experiments are "immoral, degrading, and deceptive," and will frighten a weak-minded legislature into passing an "Anti-hybridisation Act" for the further restraint of scientific curiosity.

As may well be imagined, our author has found in the course of his reading many difficulties which lie in the way of a full acceptance of the Darwinian theory. Nor is he much better satisfied with rival hypotheses. He pronounces that of Prof. Owen very vague, and that of Prof. Mivart "not very intelligible"—a perfectly just conclusion. The Duke of Argyle, he holds, leads us "at once out of the realm of science into that of miracle."

The fact remains that the question of the origin of species is yet very far from solution. Most working naturalists believe in evolution, and phenomena which scarcely admit of any other explanation, meet us on every hand. But as Sir C. Lyell and Mr. Darwin grant, of the laws of such evolution we are still profoundly ignorant. Yet these we must endeavour to ascertain before we can with any confidence hope to discover how it is brought about. Surely this task may be best accomplished by applying such theories as that of Darwin to the phenomena we observe, noting what they explain and where they fail, and modifying our hypotheses accordingly. Here, as might be expected, Mr. Maclaren takes leave of his readers. After collecting the evidence on both sides, so far at least as it is presentable in words, and intelligible to one who is not a biologist, he rejects Darwin; he does not accept Mivart, and thinking the mystery of the origin of species unexplained, he can give no hint towards its solution. We should counsel the young naturalist neither to reject nor yet to accept Darwinism, but to use it tentatively and provisionally.

One feature in Mr. Maclaren's work we have great pleasure in noticing. He writes as a scholar and a gentleman. Nowhere does he impute dishonourable motives, and nowhere does he appeal to the *odium theologicum*. Where he finds his authorities using this assassin's weapon he leaves them.

Memoir and Correspondence of Caroline Herschel. By Mrs. John Herschel, London: John Murray.

Biographies, as a class, are not the most satisfactory of literary performances. Sometimes the author is led by natural affection or especial interest to overrate the importance of his hero. Sometimes, as in books of travel, the subject is used as a mere occasion for self-display on the part of the writer. From both these faults the work before us may be pronounced free. It brings before us a personage who is well worth knowing, and its authoress suppresses her own individuality in her theme.

Every student of that important question, the "heredity of genius," must be aware that the Herschel family affords a valuable affirmative instance. Two of its members, Sir William and Sir John, have taken a position in science on which it is quite needless to enlarge, and the present inheritor of the name may be said to be following in the footsteps of his illustrious father and grandfather. But it is not so generally known that the father of Sir William Isaac was a meritorious musician, and his grandfather, Benjamin, an eminent landscape gardener; nor that the founder of the family, in company with his two brothers, left Moravia in the early part of the seventeenth century for the sake of his religion, and settled in the north of Germany. This latter fact, though it gives no evidence of extraordinary intellect, is yet a convincing proof of that fixity of purpose without which the most splendid intellect rarely leads to any tangible results. Nor is it widely known, even in cultivated circles, to what an extent Caroline Lucretia Herschel, the sister of Sir William, shared his genius, participated in his studies, and contributed to his glory. This general ignorance the work before us will remove. It has the additional merit of throwing much novel light upon the career and character of the great astronomer himself, of whom, as the authoress informs us in the preface, no good biography is in existence.

The career of Caroline Herschel, though prolonged to the unusual term of ninety-eight years, and bridging over the interval from the Seven Years' War to the Third French Revolution, offers little of a striking nature. It is throughout an example of "plain living and high thinking." She was born at Hanover in 1750, followed her brother to England in 1772, and took up her residence at Bath, where he was then established as a music-master. His professional avocations, however, were but the means to an end. Every spare moment was devoted to astronomical research and to the improvement of the necessary instruments. In this arduous undertaking his sister rendered him the most essential service. How severe were his early struggles, and how great the difficulties with which he had to contend, may be learnt from this memoir. "My only reason," says Miss Herschel, in a note addressed to her nephew, the late Sir J. F. Herschel, "for saying so much of myself is to show with what miserable assistance your father made shift to obtain the means of exploring the heavens." It would be unfair to the author to quote the details of the steps by which Sir William Herschel attained recognition, and of the share of merit due to his noble and devoted sister. As we find truly remarked in the Preface, "great men and great causes have always some helper of whom the world knows little. Sometimes these helpers have been men, sometimes (more frequently, in our opinion) they have been women who have given themselves to help and to strengthen those called upon to be leaders and workers, inspiring them with courage, keeping faith in their own idea alive, in days of darkness,

> 'When all the world seems adverse to desert.'

"Of this noble company of unknown helpers Caroline Herschel was one."

Surely it is, then, but right that she should receive her due share of honour. In this volume the reader will learn how "it was owing to her thrift and care that he was not harassed by the rankling vexations of money matters, how she had been his helper and assistant when he was a leading musician; how she became his helper and assistant when he gave himself up to astronomy. By sheer force of will and devoted affection she learned enough of mathematics and of methods of calculation, which to those unlearned seem mysteries, to be able to commit to writing the results of his researches. She became his assistant in the workshop, she helped him to grind and polish his mirrors, she stood beside his telescope in the nights of midwinter, to write down his observations when the very ink was frozen in the bottle. She kept him alive by her care; thinking nothing of herself, she lived for him." So she stood by his side for fifty years, and when the musician of Bath had become Royal Astronomer, famed as the discoverer of Uranus and maker of the most powerful telescope then known, and had passed away full of years and glory, she returned to her native country to die. Even to Germany we almost grudge the honour of giving her a grave. Profoundly, however, as she felt her brother's loss, and deprived as she was of what had been the great purpose of her life, she survived him for nearly twenty-four years, still interested in astronomical research, and almost inclined to accompany her nephew on his well known expedition to South Africa. Her letters during this period are extremely interesting. On receipt of the Astronomical Society's medal she even says: "I felt more shocked than gratified by that singular distinction, for I know too well how dangerous it is for women to draw too much notice on themselves." In a letter to her nephew she uses these memorable words: "Whoever says too much of me says too little of your father."

Nevertheless we hold that very much may be justly said in her praise without in the least detracting from the reputation of her brother. She regretted frequently that, in the first bitterness of her bereavement, she had left England. But it is very clear that had she remained in this country she would have found no satisfaction in the present. She looked upon progress in science as so much detraction from her brother's fame, and even her nephew's researches might have become a source of estrangement had she remained with him. She died early in 1848, and, singularly enough, the funeral solemnities took place at the same garrison church in which she had been baptised, nearly a century before. Royal Hanoverian carriages took part in the procession, and the coffin was covered with palm branches sent from Herrenhausen by the Crown Princess.

One most valuable lesson may be gathered from this book. Caroline Herschel did not think it needful to attitudinise on a public platform and cry out to all the winds of heaven that she "might, could, or would" do great things if not restricted by "male jealousy from graduating honours." An idle plea this, everywhere—idlest of all in England, where so many of our mightiest minds have no connection with our national universities, whether as students or professors, and only take degrees when they confer instead of receiving honour by the acceptance.* She went to work, and found no obstacle, either from laws or from social prejudice. Men saw that she was genuine, and honoured her accordingly, just as, on the other hand, men worthy of the name laugh at the "shrieking sisterhood," knowing it to be a sham. So far from self entering into the mind of Miss Herschel, she even declared, "I am nothing, I have done nothing; all I am, all I know, I owe to my brother. I am only the tool which he shaped to his use—a well-trained puppy-dog would have done as much." Such unconsciousness of its own claims and merits is often the companion of true genius. Great discoverers have said that any man, with patience and perseverence, might do all they have done. Not the less is it a mistaken estimate. Only a mind similar in its powers to that of her brother could have been trained to aid in researches like his. A lady who had discovered eight comets and effected the reduction of the places of 2500 nebulæ, who was the worthy recipient of the gold medal of the Astronomical Society and of the Gold Medal for Science given by the King of Prussia, accompanied by a letter from Alexander Humboldt outweighing a score of degrees and diplomas, might well have claimed an independent position in the scientific world. That she was content to merge her own glory in her brother's, and to live only for him, is a touching instance of the grand simplicity of her character. It is well that he was, at once intellectually and morally, not unworthy of such a self-sacrifice.

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* Many foreign critics misjudge English science on this very account. As in their own country the universities are the focus where all the greatest thinkers, the "bedeutendeste Maenner" are collected together, and whence scientific discoveries radiate out to the world, they expect the same in England; and, finding nothing in Oxford or Cambridge like what emanates from Goettingen, or Heidelberg, or Bonn, they are led to think that we are, as a nation, producing nothing.

This memoir will, we are convinced, be found pleasant and profitable reading, not by astronomers merely, or even by students of science, but by a much wider public. It will be wholesome, in these days of noisy self-glorification, to be brought into communion with a mind so pure and elevated as that of Caroline Herschel.

The Natural Foundation of Religion. By JAMES SAMUELSON. London: Longmans, Green, and Co.

WE have here a small, but pithy work, on an important and difficult subject. The author, seeking to "adapt his language to the capacity of the large class of intelligent thinkers whose daily avocations leave them little time for metaphysical studies," brings forward evidence of the existence of a personal and intelligent, and we presume consciously intelligent, Deity. His method is what is generally known as the Paleyan, or design, argument. He considers, in succession, modern doctrines and natural theology, ancient faiths and universal belief, matter and force; how the universe differs from other mechanical contrivances; the progression of nature; universal order produced by an intelligent will; the belief in the existence of an ordering intelligence practically universal; the mysterious nature of the universal intelligence the cause of extreme unbelief and of unreasoning faith; the possibility of forming a clear but limited conception of the universal intelligence; evidences of the existence of the Deity in nature; protective resemblances; mechanical appliances of insects; correlations of insects and plants; artificial and natural selection; the presence of useful minerals; the negative influence of scientific discovery on religion; obstacles to the belief in the Deity from natural evidences; the "matter and force" controversies; the intelligent employment of natural forces by man; the conception of the Deity necessarily limited, but expansive; summary of subjects of physical research affording evidence of existence and action of the Deity; the study of mankind; extended scientific knowledge beneficial to the cause of religion; changes in progress; interchange of thought between clergy and laity; modern incentives to the pursuit of wisdom,

These topics are handled clearly and fully, as far as the limited space will allow. There is a praiseworthy absence of what is known as "padding," and an amount of candour still more praiseworthy. The author is not one of those well-meaning but narrow souls who pronounce every new view concerning the *modus operandi* of the First Cause necessarily atheistic. On the contrary, he finds in the nebular hypothesis, and in the doctrine of organic evolution,—even in its Darwinian phase,—fresh evidence for the existence of an intelligent superintending power.

At the same time we doubt in how far his arguments will prove satisfactory, either to atheists or to that more numerous class who—whilst firmly believing in the existence of Deity—have found the inquiry into final causes unsatisfactory, if not delusive. To take an instance, the author, speaking of useful minerals, makes the following observations:—"We have found in operation, before man's advent, 'improving' processes similar to those which he employs for the attainment of his aims and purposes. And not only does man carry on artificial processes resembling the natural operations of the past and present, but we know that there are deposited low down in the earth's strata numerous materials whose existence has been disclosed by his intelligence, and of which the sole apparent purpose is to afford him the means of self-improvement. We may theorise, with more or less plausibility, concerning the mode in which coal was formed and deposited in the carboniferous strata, but there are two facts in connection with its presence there which cannot be disputed. One is, that coal is not a decorative object, as are trees and flowers, and that (so far as we can judge) it in no way contributes to the stability of the earth's crust, and the other that its use is to help us in a thousand different ways. The same reasoning applies to iron, and other valuable and useful metals, as well as to many well-known minerals, such as sulphur, salt, and petroleum, for the presence of which we can find no other justification than their usefulness to man. To say that they may have some other purpose unknown to us would be of no avail, for if it be worthy of consideration it must be a more intelligent purpose than that of serving man; and if those substances have been placed where they are, as who can doubt, for our uses, then they afford unmistakable evidence of the sympathy existing between the Intelligence which caused them—no matter how—to be deposited under the surface long ages since, and mankind of to-day. But even this phenomenon, although it was brought about by the apparently blind forces of Nature long before man existed to understand and appreciate its value to himself, is no less the act of an intelligent Providence than is the paternal forethought of a father who 'lays by' a provision for the education of his children before they come into the world. As in the other cases cited, it is merely a question of degree; and that a human parent does not always adopt the wise precaution referred to arises from the inferiority of his intelligence as compared with the 'Infinite Intelligence,' or to some other imperfection inherent in human nature."

Now, no one certainly will deny that coal helps us "in a thousand various ways." But in every one of these ways we are hindered, injured, or annoyed by one of its ingredients. All true coal contains sulphur, sometimes as little as a pound in the ton and sometimes exceeding a pound in the hundredweight. If we burn it in our domestic fires or in the furnaces of our steam-engines we fill the air with fumes of sulphurous acid, which is taken up by atmospheric moisture, and descends upon the ground in the form of a corrosive rain, blighting and destroying vegetation. If we use it in metallurgical operations this same sulphur injures the quality of the metal obtained. We employ the coal in our gas-works, and are still haunted by the same enemy. The gas must be purified at considerable expense, and even when all has been done that science and experience can suggest, it still retains traces of sulphur. Hence if burned in our dwellings, shops, or warehouses, it injures the colours of textile goods, weakens their fibre, and damages books, pictures, steel-wares, and a long catalogue of other substances. It may be said that we may some day remove the sulphur from the coal. But we must remember that it is too small in quantity to render such an attempt remunerative, or even self-supporting; that it is present in a form not soluble in any cheap liquid, and that it is disseminated in minute particles through the entire mass of the coal. If we apply heat we drive it off, and decompose the coal at the same time. In short, to remove it without injury to the fuel, and without seriously enhancing its price, is a problem whose solution is not even conceivable. So long as we regard coal as a something existing without any special reference to man, and of which he avails himself, taking, in the common phrase, "the rough with the smooth," all this may cause regret, but not surprise. If, on the other hand, we are told to view it as a something especially prepared for man's use, by a Being of infinite power and wisdom, we are at once staggered. Were coal the product of a finite, imperfect, human intelligence, we should pronounce it useful, certainly, but very faulty. And finding it thus faulty, can we, without irreverence, proclaim it in the sense the author takes, the work of Infinite Wisdom?

This instance of coal is no isolated case; our sulphur ores are contaminated with arsenic, our iron ores with sulphur and phosphorus, all generally in quantities too small to be of value, or to cover the process of separation, but quite sufficient to deteriorate the bodies which they thus accompany. Such facts will always incline many minds to turn away with sadness from the study of final causes, feeling that they can afford no satisfactory evidence of the rule of a Being at once all-powerful, all-wise, and all-beneficent.

Geology for Students and General Readers. Part I., Physical Geology. By A. H. Green, F.G.S., Professor of Geology in the Yorkshire College of Science, Leeds. London: Daldy, Isbister, and Co.

We have here the first part of a treatise on geology, designed for the student and the general reader, and embracing that portion of the science distinguished as physical geology. The author declares his purpose to have been the compilation of "a manual which would serve the purpose of those students who, without going very deeply into the subject, desire to know as much of the science as any man of culture may be reasonably expected to possess." We devoutly wish that every man of culture, so-called, had half the acquaintance with geology which might be gathered from this work. But unfortunately gross ignorance of geology, and, indeed, of every branch of physical science, is tolerated not merely in private men of culture, but even in literary characters,—the teachers and guides of the public. Arago well observes: "Under the brilliant and superficial varnish with which the purely literary studies of our colleges almost necessarily invest all classes of society, we generally find—let us be brief—a complete ignorance of those beautiful phenomena, of those grand laws of nature which are our best guard against prejudice." We scarcely think that Mr. Green takes a sufficiently high ground in maintaining the value of natural science "as an instrument for training the mind to reflect and reason." Natural science alone can teach us to deal with things, and to draw right conclusions from facts rightly observed. The mere mathematician—strange as the assertion may sound—is a wretched reasoner, because he invariably begs the question in a series of baseless initial assumptions. His arguments bristle with "if we only suppose," "let us assume," "let it be granted," &c. Upon these assumptions and suppositions, sometimes false and still more often doubtful, he builds a superstructure which, however correct in itself, is of necessity worthless. That the study of the classics should ever be considered superior to that of natural science as "an engine for developing the reasoning powers," is an old superstition whose origin it is not difficult to perceive, and which must ultimately fade away.

As a matter of course, in a work like this, intended for the use of the general public, originality of speculation is not to be demanded. The author declares that he has "borrowed right and left," and that he doubts "whether there is in the book, from beginning to end, that can be said to be new." But though avowedly a compilation, it is one which only a master of the subject could have produced. If it contains little that is new, it contains less that is not true, and the student may find here a solid foundation. The best authorities have been followed as regards matters of fact, and in the more speculative part of the subject the author shows great discretion. Commencing with an account of the aim and scope of geology, he passes on to a brief history of its rise and progress. He next enters upon descriptive geology, discussing in succession—denudation, the destiny of the waste produced, the method of formation of stratified rocks, the definition and classification of derivative rocks, and the method of determining the physical geography of the earth at different periods of its past history. The volcanic, metamorphic, and granitic rocks are next described, followed by a consideration of the questions how the rocks came into the positions in which we now find them, and how the present surface of the ground has been produced. In all these chapters, whilst cultivating brevity, Prof. Green not merely gives the reader results, but explains very clearly the logical processes by which such results have been reached. In the last two chapters he deals with the present physical condition of the earth, the causes of upheaval and contortion, the origin of the heat required for volcanic energy and metamorphism, examining the hypothesis of a thin crust, and reviewing the theories of Mr. Hopkins, Mr. Scrope, the Rev. O. Fisher, Prof. Sterry Hunt, and Mr. R. Mallet.

Mr. Green's concluding remarks on speculative geology may be pronounced eminently judicious. He declares that we are unable to pronounce positively upon the present state of the earth's interior, and that though the arguments in favour of a thick crust are very weighty, they are by no means conclusive. As to the vexed question of geological time, he points out a very important objection to the calculations of Sir W. Thomson, leading, as is well known, to a result far shorter than what geological and organological phenomena evidently require. Sir W. Thomson, starting from the basis of the Nebular hypothesis, assumes that the earth has been, and will be, cooling all along. Mr. Lockyer, however,* agreeing with the views of Prout and Dumas—and we may say, to a certain extent, of Mr. Ennis, as laid down in his work on the "Origin of the Stars," which will be noticed in our next issue—points out a very obvious method "by which the failing heat may have been replenished perhaps over and over again." Many of the substances provisionally regarded as elements, merely because our resources have been so far unable to effect their decomposition, may in reality be compounds formed from constituents which, during the early part of a star's career, existed in a free state. But when the temperature of the heavenly body was so far reduced as no longer to keep these primeval elements in a free state, then combination took place, liberating a very considerable amount of heat. "Thus," Mr. Green continues, "the life of a star may not have been one continuous process of cooling, but it may have every now and then fired up afresh, and the time taken to reduce it to a certain temperature may have been much longer than if it had gone on always steadily losing heat." We may add that this view agrees not badly with certain well-known astronomical phenomena. Nor should the very untrustworthy nature of mathematical speculation, where not constantly controlled by an appeal to actual facts, be left out of view. If mathematicians were till lately in error to the extent of 1-30th part in such a comparatively simple matter as the distance of the earth from the sun, what weight can we seriously attach to Sir W. Thomson's speculation as to the past direction of the solar system?

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* See CHEMICAL NEWS, Oct. 3, 1873.

In the dispute between the Uniformitarians and the Catastrophists, Mr. Green takes an intermediate position. He holds it highly probable that "when the earth was hotter than it is now all the phenomena which depend directly or indirectly on the internal heat, such as metamorphism, volcanic energy, and contortion, must have been proportionally more energetic; and if the sun was at the same time hotter, all the geological operations depending on meteorological conditions, such as denudation, must have gone on faster and on a larger scale than now." Still he holds that, for the period over which our researches extend, Uniformitarianism may be practically correct.

As regards the climatic changes which the earth has undergone, such as the glacial epochs and the genial Miocene period, our author inclines to the views expounded by Mr. J. Croll, in his "Climate and Time in their Geological Relations: a Theory of the Secular Changes of the Earth's Climate."

We shall look forward with interest to the appearance of the second part of the work before us, and we think we may safely congratulate the Yorkshire College of Science on including in its professorial staff so able an expounder of a fascinating and important science.

An Introduction to Animal Morphology and Systematic Zoology. By ALEXANDER MACALISTER, M.B., Professor of Comparative Anatomy and Zoology, University of Dublin. Part I.: Invertebrata. London: Longmans, Green, and Co.

THE author of this work states in his Preface:—"In teaching zoology and comparative anatomy I have found that students desire to have a text-book in their hands to enable them to learn the terminology of the science, and by giving them a connected view of the varieties of animal forms to assist them in remembering the practical instructions of the class-room."

This want he has endeavoured to meet, and, in our opinion, with good success. Of course minute details must not be looked for in a work which aims at giving a general view of morphology, a sketch of animal geography, and a structural survey of the Invertebrates from the Protozoa up to the Hymenoptera, within the compass of some 400 pages. But the space at command has been skilfully utilised. Perhaps the least commendable feature of the book is the intensely technical character of its language, which in many passages must be simply unintelligible to the private student. It has often struck us that the Germans have a great advantage in the circumstance of having at command technical terms formed from their own language and not borrowed from the Latin and Greek. The lesser flexibility of the English tongue prevents our imitating them fully in this respect, but we are confident that in many cases plain English terms might be found to supersede the foreign terminology now in vogue, and which is upheld by a prejudice resembling that which induces physicians to write their prescriptions in Latin, and lawyers to cultivate a peculiarly incomprehensible jargon.

We are glad to find that Prof. Macalister avoids the Cuvierian error of placing the mollusca above the articulata. We think that there is evidence sufficient to warrant us in regarding the antennæ of insects as organs of smell, even if that should not be their only function. Like all authorities on animal classification, Prof. Macalister fails to see that the so-called orders of insects have a strong claim to be regarded as groups of a higher rank. The conflicting views on the origin of species are briefly stated, without any account of the arguments on either side. The important truth that species, genus, &c., must be looked on as more or less arbitrary, ideal conceptions, is clearly brought forward. Into descriptive natural history the author, of course, cannot enter; but one fact, incidentally mentioned, may interest our readers. The arm of a cephalopod of the genus Architeuthis —which would be commonly called an octopus, or sea-devil— driven ashore on the west coast of Ireland in the year 1875 measured 30 feet in length. This, as the author hints, furnishes some basis for the old Scandinavian legend of the Kraken.

For all students who are in a position to have its technical language explained this work will prove a most valuable textbook. For the benefit of those less favourably situated we should venture to suggest the addition of a glossary.

Bubbles from the Deep. By Arthur Greaves. Halifax (Nova Scotia): M. A. Buckley.

On receiving this little volume we were somewhat perplexed at its title. However, in these days the name of a book is not always intended to throw any light upon its subject. So we commenced an examination of the work, expecting a report on the results obtained by deep-sea dredging. But to our surprise, we found that the contents were poetry. We were, therefore, about to lay the book aside, leaving it for more experienced and competent judges to pronounce on its merits, when we accidentally came upon a kind of appendix. In this figured a correspondence between the author and a real or imaginary friend rejoicing in the uncouth name of "Phineas Phillgro." This latter worthy asks for the privilege of annexing to the book an effusion of his own, and unfortunately receives Mr. Greaves's consent. The addition thus made is a piece of wretched doggrel, expounding the loathsome doctrine known by the scarcely less loathsome name of "miscegenation." Mr. Phillgro thinks that the Aryan race in America is decaying, and proposes its resuscitation with the "rich and luscious blood of the tropics." Why not go a step further? Is it not just possible that the blood of the gorilla or the chimpanzee might prove richer and more luscious still? But, in all sober sadness, if any part of the Aryan race, whether in America or Europe, is degenerating, is it not better to attempt its restoration, not by unions which it is revolting to contemplate, but by the removal of the causes which have led to such degeneracy? These causes are many, and well known. An intermixture of different branches of the Aryan race may have had beneficial results. A fusion of different "races"—if this be the legitimate term—has proved disastrous wherever tried. What strain, for instance, is viler than the half-breeds of Macao? We should seriously advise Mr. Greaves, if he wishes his poems to circulate in the land of his forefathers, to renounce "Phineas Phillgro and all his works.

PROGRESS IN SCIENCE.

PHYSICS.

An Address on the "Fundamental Principles of Scientific Arctic Investigation," was delivered, in September last, before the 48th Meeting of German Naturalists and Physicians at Graz, by Lieut. Charles Weyprecht. The author argues that the scientific results obtained by former expeditions bear no comparison to the enormous sums expended upon them. Within the last fifty years England and America alone have sent out more than twenty-five large or small expeditions, at a cost of far beyond £1,000,000 sterling. The most important scientific results of this long series of costly expeditions are—the discovery of the magnetic pole, the determination of the physical constants for a number of points, a more extended knowledge of the Natural History of high northern regions, and, finally, the topography in detail of a cluster of islands of little importance. But the gains to Natural History are locally far too limited considering the number of voyages, nor have the researches been systematically conducted, while the physical observations—owing to the manner in which they have been made—offer us little more than unconnected average values, which, through local influences and annual fluctuations, neither to be avoided nor overcome, possess less value than generally has been accorded to them. We are still wanting from the Arctic regions even one series of observations upon the disturbances of the three magnetic elements. The data furnished by the Expeditions are confined to absolute determinations—sadly wanting in accuracy, because exposed to every casual disturbance—and to observations upon variations of declination. The disturbances of the horizontal intensity and of inclination have been utterly neglected. Of the relation in which the horizontal and vertical components of the earth's magnetism stand to each other during the disturbances we know nothing, and are therefore unable to decide whether the total force may not rather simply change in direction, and not in degree of strength. As to intensity and inclination, there is not a point from which we possess sufficiently accurate data to serve, after a lapse of years, as a basis for determination of secular changes. We might almost say that we know not much more of Nature's doings, in high northern and southern latitudes, than just enough to show us how important a thorough scientific investigation of these regions is to natural philosophy in all its branches. If we enquire why the scientific results obtained are so scanty, we discover that the fault lies less in the observations made than in the generally false principles on which hitherto Arctic Expeditions have been sent out—principles which, in most cases, have actually been direct hindrances in the way of true scientific research. The grand fault has been that the first object of almost all the Expeditions has been geographical discovery. The investigation of those vast unknown regions about the Poles will and must be pursued, regardless of cost of money and human life, so long as man makes any pretension to progress. But its great object must be a nobler one than mapping and naming icebound islands, bays, and promontories, in this or that language, or reaching a higher latitude than any predecessor. Descriptive geography neither can nor should be excluded, but must not stand as the object first in rank: in uninhabited and uninhabitable latitudes, which by force of their physical conditions are important for science alone, it has value only in so far as the meteorological, physical, and hydrographical phenomena of the earth are influenced by the character of the land; broad and general sketches therefore suffice. The geographical object of former Expeditions must bear the blame that the stations of observation are crowded so one-sidedly within a single region. In the search for a North-West passage, and in the attempts to reach the North Pole, the same routes have been continually adopted with little variation, and all else overlooked. To be sure some of those Expeditions had specially the sad object of seeking the remains of Franklin's disastrous Expedition. In these, the employment of the sledge attained that extraordinary development which has excited such universal wonder and imitation. But where the sledge stands out prominent, scientific research can play but a secondary part. The journeys occupy the best time in spring and, autumn, and never admit of that repose which is essential to thorough observation. To what extent scientific research has been neglected in the greed for discovery, the best proof is that it is only two years that the first party has wintered for purposes of science in the Archipelago of Spitzbergen, geographically well known and approachable even in 80° lat. every year almost without obstacle, although these islands form one of the most important and favourably situated points for observation in the Arctic regions. It is to the Expeditions to Spitzbergen and Siberia, fitted out at comparatively small cost, that we owe our most thorough studies of the flora and fauna of this and the antediluvial world, of the effects of the Arctic conditions on animal and vegetable life, &c. A second cause of inadequate results lies in this—that all Expeditions have been single and independent, and afford no synchronous observations for comparison. Where and whenever the forces of Nature, and the physical phenomena which they produce, are the object of study, simultaneous observations on many points are a fundamental condition of success. In peopled countries, this condition in a degree fulfils itself over the greatest possible extent of surface, through the multitude of chance observers. In the Polar regions the observer must depend on himself; the simplest and most important data are wanting; for instance, the extent of territory covered by a phenomenon. In a far higher degree is this true in regard to those phenomena not perceptible by the senses, and only perceived by the aid of instruments. Nothing but simultaneous and most careful observations, made at numerous stations more or less widely separated, can yield decisive results. After Gauss and Weber had introduced the synchronous magnetic *termdays*, the science of Terrestrial Magnetism very soon burst the narrow bounds, in which until then it had been restrained. Animated by their success, England established her colonial observatories, and by them proved the subjection to natural laws of all magnetic phenomena; but none of these stations reached the Arctic regions, the most northern being in latitude 61°. However interesting and important their observations are, still they do not suffice to give us that view of the joint action of the combined forces of terrestrial magnetism in high latitudes—the extensive home of disturbance—which is absolutely indispensable to a sound theory. They leave us in the dark as to the position of the centres of disturbance, as to the limits of particular movements, as to their synchronism at different distances as to the manner in which the separate oscillations exhibit themselves along the same parallel in different longitudes. Hence all conclusions as to the influence of local circumstances upon the strength and character of the disturbances fail. The English observations have proved that perturbations at various places in various years cannot be compared, since, for instance in Toronto, they, in one year, amounted for the declination to three times, and for the horizontal intensity to six times, as much as in another. It would therefore lead to utterly false conclusions if the Toronto, Sitka, or Athabasca observations of different years be compared in the matter of intensity. What may be said of magnetic disturbances is equally applicable to the northern light. There are many reasons to believe that this phenomenon in high northern latitudes has but a very local character, a point only to be decided by synchronous observations. For here also it would be false to compare different years at different points with each other. Different places the same year, or different years for the same places, can only be compared, Through the frequent neglect of this axiom in analysing auroral phenomena many an error has crept in. The entire meteorology of our day rests upon comparison; all the successes of which it can boast—the laws of storms, the theories of the winds—are results of synchronous observations, The average values of the meteorological constants of particular places are most important to the knowledge of the physical conditions of the earth, but they suffice no longer as soon as the question is—What are the laws which govern the changes to which they are subject? They can answer the *how*, but are rarely equal to the *why*. The accessibility of the Arctic interior from different quarters is constantly discussed in all scientific circles. It has been common to draw conclusions from the favourable or unfavourable experiences of Arctic voyagers by different routes and at different times, which conclusions have afterwards proved to be mistaken, because the difference in the condition of the ice in different years has not been taken into account. In the years 1871 and 1874 the ice on the same meridian near Nowaja-Zemlja began at 78° lat., but in 1872 it reached 6° farther south. Now, it is probable that on the opposite side of the Arctic basin—the American coast—the case during this period was precisely the reverse. But this we cannot decide with certainty, because we do not know whether the exceptional increase of ice on this one side is necessarily conjoined with a decrease on the other; or whether perhaps the Arctic basin does not contain totally different amounts of ice in different years. We need that general view of the entire mass of ice and its movements which can only be gained by simultaneous observations at various points. One-sided judgments, formed at a single point, whose conditions depend on the accidents of the year, will never enable us to draw correct conclusions as to the accessibility of the Arctic interior. For the descriptive branches of science synchronism is of less importance: these demand continuous systematic study. "Voyages have enlarged the catalogues," Prof. C. Vogt writes me, "but only continued observations on the spot produce the deeper scientific results." To this the unscientific man is inadequate, however industrious a collector he may be. If our object be genuine progress in Natural History, the aid of the man of science is absolutely necessary, which we have had in but few instances. In view of the ever-increasing interest in Arctic research, and of the readiness with which governments and private individuals are continually furnishing the means for new Expeditions, it is desirable to establish the principles on which they should be sent out, so that their utility to science may be in proportion to the great sacrifices made, and they be relieved of that adventurous character which can only be prejudicial to science. The following points, the author considers, will meet the requirements set forth above:—

1. Arctic research is of the highest importance to the knowledge of Nature's laws.
2. Geographical discovery in those regions has a higher value in so far only as it opens the field to scientific research in the narrower sense of the term.
3. Arctic topography in detail is but of secondary importance.
4. The geographic pole has for science no greater significance than any other point in the higher latitudes.
5. Stations of observation are—without regard to their latitude—the more favourable in proportion to the comparative intensity of the phenomena under investigation.
6. Independent series of observations have but secondary value.

It is not necessary to extend our sphere of observations into the very highest latitudes in order to secure scientific results of the greatest importance. For instance, stations at Nowaja-Zemlja (76°), Spitzbergen (80°), East or West Greenland (76°—78°), North-America east of Behring's Strait (70°), Siberia at the mouth of the Lena (70°), would give us a zone of observation quite around the Arctic regions. Greatly to be desired are stations near the centres of magnetic intensity. The observations there would be connected with our own through the stations already established near the Polar circle, which only need to be strengthened. The means expended on any one of the more recent attempts to reach the highest latitude would be amply sufficient to sustain all these stations for a year. The object of these Expeditions would be, with instruments precisely alike, governed by precisely the same instructions, and for a period of one year at least, to record a series of the utmost possible synchronous observations. Attention should be directed above all to the various branches of physics and meteorology, as being of the highest degree of importance; then to botany, zoology, and geology; and, lastly, to geographical detail. Should it be possible to establish, in connection with these Arctic stations of synchronous observations, one or more in the Antarctic regions, we might expect results of inestimable value.

Several important papers have been read before the Physical Society since the publication of the April number of this Journal. At the meeting on April 8th Prof. G. Carey Foster, F.R.S., described an instrument which he has constructed for illustrating the law of refraction. It is founded on the well-known method of determining the direction of the ray after refraction by means of two circles described from the point of incidence or centre, the ratio of whose radii is the index of refraction. A rod representing the incident ray is pivoted at the point of incidence, and projects to a point about 4 inches beyond. To this extremity is attached a vertical rod, which slides through a nut in another rod also pivoted at the point of incidence. The lower extremity of the vertical rod is attached to a link, so fixed as to constrain it to remain vertical. By this means the two rods always represent respectively the incident and refracted rays, and the index of refraction can be varied by altering the position of the nut through which the vertical rod passes on the rod to which it is attached.

At the same meeting Prof. Foster exhibited a simple arrangement for showing the interference of waves, and a method—suggested by Prof. Kundt—for showing, in a simple manner, that the air in an organ-pipe is in a constant state of alternate condensation and rarefaction.

At the meeting on April 29th the Secretary read a communication from Sir John Conroy, Bart., "On a Simple Form of Heliostat." The author substitutes two silvered mirrors for the looking-glasses usually employed, and he has shown that the loss of light with this arrangement is less than when the light is once reflected from a looking-glass.

Mr. S. P. Thompson described some experiments which he had made on the so-called "Etheric Force." If the secondary current from an induction coil be used instead of a current direct from the battery the effects are much more marked. The secondary current of a Ruhmkorff's coil is made to traverse a short coil of wire, which is thoroughly insulated from the internal core, and into the circuit an arrangement is introduced by means of which the spark may be made to traverse a variable thickness of air in its course round the short coil. It is found that if this spark is very short the spark obtained from the internal core is also short; but as we increase the thickness of air to be traversed, the spark which may be drawn off increases. The greatest effect, however, is produced when one terminal of the coil is connected with the earth, the spark then obtained being about ½ an inch in diameter. Mr. Edison considered that the spark was retro-active, but Mr. Thompson showed by an experiment that deficient insulation might lead to such a conclusion. He then proceeded to show that just as the charge given to a gold-leaf electroscope is at times positive, and at times negative, without any apparent reason for the change, so, if the core of the arrangement employed be connected with a Thomson's galvanometer, the needle will be found to wander irregularly about the scale on both sides of the zero. In order to show that these experiments are identical with those conducted as originally described by the discoverer, the terminals of the induction coil were connected with the coil of an electro-magnet, the same means of including a layer of air in the circuit being introduced. The effect in this case was found to be precisely similar to that obtained with the special arrangement previously used. With a brush discharge a Geissler's tube could be illuminated, and when the layer of air was infinitesimal the spark produced was also infinitesimal. It was then shown that if the spark at the point of contact in the key, when a direct battery current traverses the coil, be done away with by shunting the extra current which gives rise to it, no spark can be obtained from the core. It thus appears that no spark is obtained when there is no necessity for an inducing current to accumulate until it has sufficient tension to leap over a resisting medium, and that, as the thickness of this resisting medium increases, the spark obtained becomes greater. Evidently, on these occasions, the charge has time to attract unlike and repel like electricity in the core, and if a conductor in connection with the earth be presented to this core the like electricity will escape: hence a spark will result. As soon, however, as the tension has become sufficient to leap over the layer of air, it will be necessary to restore equilibrium in the core. Hence there will be a return spark in the opposite direction. From these experiments Mr. Thompson concludes that the phenomena observed may be explained by the ordinary laws of induction.

On June 10th Mr. W. J. Wilson explained a reflecting tangent galvanometer, which he has recently designed, for the purpose of exhibiting the indications of the instrument to an audience, and so arranged that the divisions on the scale show, without calculation, the relative strengths of different currents. The beam of light, after passing through a small orifice traversed by cross wires, is reflected vertically by a fixed mirror; the ray then passes through a lens, and is again reflected from a small plane mirror parallel to the first, which is rigidly fixed below a small magnetic needle. By this means the ray becomes again horizontal, and, since the light now falls on the second mirror always at the same angle, the extent of motion of the ray is identical with that of the needle, and, if the scale be one of equal parts placed in the magnetic meridian, the indications on it will be proportional to the tangents of the angles, and, therefore, to the strengths of the currents. The needle and mirror are suspended by a silk fibre, and a bent strip of aluminium, the ends of which dip into water in an annular trough, is attached to the needle in order to check its oscillations. A series of observations, taken with varying resistances introduced into the current, showed that the indications are very reliable.

Prof. G. Fuller, C.E., described his "Electric Multiplier," an instrument which may be looked upon as an automatic electrophorus. An insulated plate of vulcanite is supported in a vertical position, and on each side of it is an insulated metallic plate, and these can be moved together to and from the vulcanite by rotating a handle. When these plates are far apart, two metallic arms, provided with points, are made to pass one on each side of the vulcanite plate. One of these is insulated, and is provided with a rod terminating in a knob, which at a certain point in its path almost touches the metallic plate on the opposite side of the sheet of vulcanite. The other arm is in connection with the earth. The action of the instrument is as follows:—A charge of, say, negative electricity having been given to the insulated arm, it is passed over the face of the vulcanite, while positive is drawn up from the earth and thrown upon the opposite face by the uninsulated series of points. These arms are then removed, and the two metallic plates are brought into contact with the vulcanite. Call the side of the plate charged with negative electricity A, and the other B. The negative of A induces positive on the near face of its metallic plate, and repels the negative. This passes, by a strip of tin-foil joining the two faces of the vulcanite, to the other metallic plate, neutralising its free positive; and when the plates are moved away from the vulcanite, that from A is charged with positive, and that from B with negative. Before reaching its extreme position, this latter communicates its charge to the insulated arm by the brass knob, and the electricity is then distributed over the face A. At the end of its path, B is momentarily connected to earth. It will be evident that the effect of again bringing the plates in contact is to increase the charge of positive electricity on the metallic plate opposite the face A. With the small model exhibited Prof. Fuller has frequently obtained sparks an inch in length.

Prof. Guthrie exhibited Prof. Mach's apparatus for sound reflexion, which is one of an interesting series of appliances designed by him for the demonstration of certain fundamental principles in physics. It consists of a mathematically exact elliptical tray, highly polished, and provided with a close-fitting glass cover. The tray is covered with pulverised dry silicic acid, and a Leyden jar frequently discharged between two small knobs at one of the foci, when the silicic acid arranges itself in fine curves around the other focus, On April 28th Dr. Andrews, F.R.S., delivered a lecture before the Chemical Society "On Certain Methods of Physico-Chemical Research." The lecturer began by describing the simple form of apparatus which he employed many years ago in his researches on the heat evolved in the combination of oxygen, chlorine, bromine, &c., with other bodies. In every case the bodies to be combined were enclosed in a vessel surrounded with water, and the combination was effected either by the ignition of a fine platinum wire, or, where they acted directly upon one another, by the fracture of a glass capsule containing one of the combining bodies, the heat being measured by the rise of temperature of the water. He next referred to the arrangement by which he had been the first to decompose water so as to render visible the hydrogen and oxygen, and to measure their relative volumes, by means of atmospheric electricity and of the electrical currents from the ordinary machine. For this purpose fine platinum wires were hermetically sealed into fine thermometer tubes, which were then filled with dilute sulphuric acid by withdrawing the air by ebullition. The same current of frictional electricity will decompose the water in almost an indefinite number of such couples arranged in a consecutive series. Capillary tubes of this kind may be employed for eudiometric experiments, which would be exceedingly tedious in wide tubes. Thus oxygen gas can be at once absorbed by passing the silent discharge through it while standing over a solution of iodide of potassium. By means of the air-pump it is easy, with a gentle exhaustion, to expand the gas so that it may fill the whole tube, while the open end is immersed in the liquid which it is desired to introduce. On removing the pressure, the gas will be in contact with the new liquid. The lecturer exhibited some of the original tubes with which Prof. Tait and he first determined that ozone is a condensed form of oxygen, and explained a form of apparatus by means of which this important fact can be exhibited as a class experiment. A full description of this apparatus will be found in his lecture on ozone, which was delivered some time ago before the Royal Society of Edinburgh, and has since been published by the Scottish Meteorological Society. With this apparatus the lecturer has been able to determine that chlorine gas undergoes no change of volume from the prolonged action of the electrical discharge. His experiments on this subject have not yet been published, but they were made under singularly favourable conditions for discovering a very small change of volume in the gas, if any such change had occurred. The lecturer, in the next place, briefly alluded to the method he formerly employed for determining the latent heat of vapours, of which a detailed account was given in a former communication to the Chemical Society. The apparatus employed admits of exact experiments being made on a small scale, and consequently on substances in an absolutely pure state—an object of even greater importance in enquiries of this kind than in ordinary chemical analysis. He remarked that a large field for investigations in this part of the domain of science lay comparatively uncultivated, and would yield a rich harvest of results to any one who would enter upon it. Passing from this subject, the lecturer described a dividing and calibrating machine, which he contrived some years ago for the special work in which he has been engaged, and which has given to many of his investigations an accuracy otherwise hardly obtainable. He has been enabled by means of it to construct thermometers whose readings are absolutely coincident throughout every part of the scale, and to calibrate with almost perfect accuracy the glass tubes used in his pressure experiments. It would be impossible in an abstract to describe the construction of this machine, but it may be important to mention that the screw which moves the microscope or divider is a short one, of remarkable accuracy, constructed by Troughton and Simms. The last subject treated was the lecturer's method of investigating the properties of gaseous and liquid bodies at high pressures and under varied temperatures. By means of his apparatus, which was exhibited to the meeting, pressures of 500 atmospheres can be readily observed and measured in glass tubes—in a word, a complete mastery obtained over matter under conditions hitherto beyond the reach of direct observations. This has been effected by a novel mode of *packing* a fine steel screw, so that while entering a confined portion of water no leakage whatever occurs under enormous pressures, and also by a peculiar method of forming a tight junction between glass and metal. The lecture was concluded by a short statement of the more important results lately communicated to the Royal Society on the properties of matter in the gaseous state.

Prof. Balfour Stewart, LL.D., F.R.S., has constructed a new instrument for measuring the direct heat of the sun. The instrument generally employed for giving the radiant energy of the sun's rays acts upon the following principle: —In the first place the instrument is sheltered from the sun, but exposed to the clear sky, say, for five minutes; let the heat so lost be termed r. Secondly, the instrument is turned to the sun for five minutes; let the heat so gained be termed R. Thirdly, the instrument being now hotter than it was in the first operation, is turned once more so as to be exposed to the clear sky for five minutes while it is shielded from the sun; let the heat so lost be termed r'. It thus appears that r denotes the heat lost by convection and radiation united when the instrument, before being heated by the sun, is exposed for five minutes to the clear sky, while r' denotes the heat lost by these same two operations by a similar exposure after the instrument has been heated by the sun; and it is assumed that the heat lost from these two causes during the time when the instrument is being heated by the sun will be a mean between r and r', and hence that the whole effect of the sun's rays will be in reality—

$$R+\frac{r+r'}{2}$$

Now although this assumption may in the average of a great number of experiments represent the truth, yet in many individual cases it may be far from being true. In the new instrument the causes of variability are not allowed to operate. It consists of a large mercurial thermometer with its bulb in the middle of a cubical cast-iron chamber, this chamber being of such massive material that its temperature will remain sensibly constant for some time. The chamber with its thermometer has a motion in azimuth round a vertical axis, and also a motion in altitude round a horizontal axis. A 3-inch lens of 12 inches focal length is attached by means of a rod to the cubical chamber, so as to move with it. Thus the whole instrument may be easily moved into such a position that the lens as well as the upper side of the chamber, which is parallel to the plane of the lens, may face the sun, and an image of the sun be thrown through a hole in the side of the chamber upon the thermometer bulb. The stem of the thermometer protrudes from the chamber. A screw, somewhat larger in diameter than the bulb of the thermometer, is made use of to attach the thermometer to its enclosure, and a smaller screw, pressing home upon india-rubber washers enables the thermometer to be properly adjusted and kept tight when in adjustment. The internal diameter of the chamber is 2 inches, while the bulb of the thermometer is about 1½ inches in diameter. The scale of the thermometer is very open, more than an inch going to one degree. Prof. Stewart has generally allowed the image of the sun given by the lens to heat the thermometer bulb for one minute, during which time an increase of temperature, not exceeding in any case 2°, has been produced. A practical objection has been provided for by Prof. Stewart. The scale being so very open, the stem comprehends only a few degrees; frequently, therefore, the temperature is such that the extremity of the mercurial column is either below or above the stem. Now the thermometer has a small upper chamber, and by means of a method of manipulation well known to those who work with thermometers, it is possible to add to or take away from the main body of mercury in the bulb so as to keep the end of the mercurial column always in the stem. But for a thermometer with such a large bulb, frequent manipulation of this kind is not unattended with danger to the bulb. To remedy this defect without altering the size of the bulb, Prof. Stewart proposes for a permanent instrument a stem, say 18 inches long, with a bore of such diameter that the stem should embrace a range of temperature between 20° F. and 92° F. Thus somewhat less than 5° will go to the inch. The stem might be protected from the risk of accident by an appropriate shield. Let such a thermometer be heated for two minutes, and the size of the lens be somewhat increased. In this case a rise of something like 5° F. will be obtained, and this heating effect might very easily be estimated to one-hundredth of the whole, while the same thermometer would serve for all the temperatures likely to occur in these islands during the course of the year. A pasteboard cover gilded on the outside is made to surround the chamber, and between the lens and the chamber there is a pasteboard shield, with a hole in it, to permit the full rays from the lens to pass—the object of this shield being to prevent rays from the sun or sky from reaching the instrument. In such an instrument r, or the change taking place in the thermometer before exposure to the sun, will in all probability completely disappear, while r' will be extremely small. At any rate we may be quite certain that—

$$R+\frac{r+r'}{2}$$

will accurately represent the heating effect of the sun.

At a meeting of the American Academy of Arts and Sciences held on the 8th March, 1876, the Rumford Medal was awarded to Dr. J. W. Draper for his researches in radiant energy. In presenting the medals, the President (the Hon. Charles Francis Adams) referred to Dr. Draper's researches as follows:—In 1840 Dr. Draper independently discovered the peculiar phenomena commonly known as Moser's images, which are formed when a medal or coin is placed upon a polished surface of glass or metal. These images remain, as it were, latent until a vapour is allowed to condense upon the surface, when the image is developed and becomes visible. At a later period he devised the method of measuring the intensity of the chemical action of light, afterward perfected and employed by Bunsen and Roscoe in their elaborate investigations. This method consists in exposing to the source of light a mixture of equal volumes of chlorine and hydrogen gases. Combination takes place more or less rapidly, and the intensity of the chemical action of the light is measured by the diminution in volume. No other known method compares with this in accuracy, and most valuable results have been obtained by its use. In an elaborate investigation published in 1847 Dr. Draper established experimentally the following important facts:—1. All solid substances, and probably liquids, become incandescent at the same temperature. 2. The thermometric point at which substances become red-hot is about 977° F. 3. The spectrum of an incandescent solid is continuous; it contains neither bright nor dark fixed lines. 4. From common temperatures nearly up to 977° F., the rays emitted by a solid are invisible. At that temperature they are red, and, the heat of the incandescing body being made continuously to increase, other rays are added, increasing in refrangibility as the temperature rises. 5. While the addition of rays so much the more refrangible as the temperature is higher is taking place, there is an increase in the intensity of those already existing. Thirteen years afterward Kirchhoff published his celebrated memoir on the relations between the coefficients of emission and absorption of bodies for light and heat, in which he established mathematically the same facts, and announced them as new. 6. Dr. Draper claims, and we believe with justice, to have been the first to apply the daguerreotype process to taking portraits. 7. Dr. Draper applied ruled glasses and specula to produce spectra for the study of the chemical action of light. The employment of ruled metallic specula for this purpose enabled him to avoid the absorbent action of glass and other transparent media, as well as to establish the points of maximum and minimum intensity with reference to portions of the spectrum defined by their wave-lengths. He obtained also the advantage of employing a normal spectrum in place of one which is abnormally condensed at one end and expanded at the other. 8. We owe to him valuable and original researches on the nature of the rays absorbed in the growth of plants in sunlight. These researches prove that the maximum action is produced by the yellow rays, and they have been fully confirmed by more recent investigations. 9. We owe to him, further, an elaborate discussion of the chemical action of light, supported in a great measure by his own experiments, and proving conclusively—and, as we believe, for the first time—that rays of all wave-lengths are capable of producing chemical changes, and that too little account has hitherto been taken of the nature of the substance in which the decomposition is produced. 10. Finally, Dr. Draper has recently published researches on the distribution of heat in the spectrum, which are of the highest interest, and which have largely contributed to the advancement of our knowledge of the subject of radiant energy. Through ill-health, Dr. Draper was unable to receive the medal in person. He therefore sent the following letter, which was read by Mr. Quiney:—

"To the American Academy of Arts and Sciences.—Your favourable appreciation of my researches on radiations, expressed to-day by the award of the Rumford Medal—the highest testimonial of approbation that American science has to bestow on those who have devoted themselves to the enlargement of knowledge—is to me a most acceptable return for the attention I have given to that subject through a period of more than forty years, and I deeply regret that through ill-health I am unable to receive it in person. Sir David Brewster, to whom science is under so many obligations for the discoveries he made, once said to me that the solar-spectrum is a world in itself, and that the study of it will never be completed. His remark is perfectly just. But the spectrum is only a single manifestation of that infinite ether which makes known to us the presence of the universe, and in which whatever exists—if I may be permitted to say so—lives and moves and has its being. What object, then, can be offered to us more worthy of contemplation than the attributes of this intermedium between ourselves and the outer world? Its existence, the modes of motion through it, its transverse vibrations, their creation of the ideas of light and colours in the mind, the interferences of its waves, polarisation, the conception of radiations and their physical and chemical effects—these have occupied the thoughts of men of the highest order. The observational powers of science have been greatly extended through the consequent invention of those grand instruments, the telescope, the microscope, the spectrometer. Through these we have obtained more majestic views of the nature of the universe. Through these we are able to contemplate the structure and genesis of other systems of worlds, and are gathering information as to the chemical constitution and history of the stars. In this noble advancement of science you, through some of your members, have taken no inconspicuous part. It adds impressively to the honour you have this day conferred on me, that your action is the deliberate determination of competent, severe, impartial judges. I cannot adequately express my feelings of gratitude in such a presence publicly pronouncing its approval on what I have done.—I am, gentlemen, very truly yours, John W. Draper."

Microscopy.—In a memoir devoted to the subject of amyloid degeneration of the kidney, liver, and spleen, which appears in a recent part of the "Archives de Physiologie," M. Cornil gives the results of his experiments with several new colouring matters. Two of these were methyl-aniline violets discovered by M. Lauth; the third was a violet discovered by Dr. Hofmann, of Berlin. The preparations can be stained with these violets either when fresh or after being hardened in spirit; and the colouring agents have this peculiarity, that certain tissues, as cartilage, decomposes them into a violet-red and a blue-violet, each of which becomes fixed in different elements of the tissue; the hyaline matrix, for example, assuming a red colour, whilst the nuclei and cellules, as well as the cartilaginous capsules, become of a blue-violet tint. The normal tissues of the liver, kidney, and spleen, however, do not decompose the violets, but, when amyloid degeneration is present, the degenerated and semi-transparent parts resembling colloid become of a violet-red, whilst the normal elements are tinted of a violet-blue, and thus a means equal, if not superior, to that of iodine is afforded, by which the changes may be followed.

The researches of the Rev. W. H. Dallinger and Dr. Drysdale, on monads with high powers, have led to some improvements in the mode of illumination employed in such observations. Great stress is laid upon the necessity of accurate centreing throughout every part of the microscope. The contrivance used in centreing the condenser consisted of an accurately centred diaphragm beneath the optical portion, having an aperture of not more than the ninetieth or hundredth of an inch: by means of the adjusting screws the image of this aperture is brought carefully to the centre of the field of a moderate power. If the illuminating pencil be now carefully manipulated, and the 1-50th objective be put on, it will be found that the image can be brought to a focus presenting a central disc of light with a margin of the black diaphragm. By an accidental movement of the mirror Mr. Dallinger found that this minute spot of light might be spread over the entire field, presenting a disc, with an intense minute speck in the centre, with an equal diffusion of rays all round, excepting that the illumination grows uniformly less as it reaches the margin of the field. This light was found to be extremely favourable for the display of minute detail under such high powers as the 1-25th and 1-50th. The difficulty in using this mode of illumination was that its production was a matter of great uncertainty. At last it was found that great precision was required in the position of the lamp-flame, which needed as accurate centreing as the test of the apparatus. This was at last effected by means of a lamp with vertical and horizontal screw adjustments, which enabled the narrow edge of the flat flame employed to be accurately brought into position. The lamp is figured in the "Monthly Microscopical Journal" for April.

The following process is recommended by Mr. C. J. Müller for cleaning Foraminiferæ from chalk. Having obtained a quantity of the shells by the usual process of elutriation, mix it with four or five times its bulk of silver sand which has previously been well washed, and put the mixture in a long 2 or 3 ounce phial with a sufficiency of water. Shake up the whole (not violently) for ten or fifteen minutes, and then pour off the turbid water. Renew this operation as many times as you like. The Foraminiferæ will always settle down last, and form a distinct stratum upon the surface of the deposited sand. The sand when shaken up with the shells will act as a gentle rasp, and remove from their surface most of the hard granular particles which injure their appearance. When the cleansing operation is completed the water will rapidly clear upon the mixture being set aside for three or four minutes. There is no difficulty in separating the shells from the sand. Let the whole quietly settle down; pour off the clear water, and allow the whole to rest for a few minutes. Now add a fresh supply of water rather forcibly, when the shells will immediately rise, leaving the sand below. The water with the shells must now be poured off, before they have time to settle down, into another vessel, where they may subside. The deposit may then be dried and mounted as required.

A series of very successful micro-photographs have lately been presented to the Royal Microscopical Society: they are the work of Edward H. Gayer, Professor of Surgery in the Medical College, Calcutta. The camera and other apparatus are arranged on a strong table, 2 feet wide and 12 feet or more long, the chief peculiarity being the facilities afforded for manipulating the mirror, microscope, and illuminating apparatus—a point upon which great stress is laid by Mr. Gayer. To effect this the operator stands near the mirror, which receives the direct rays of the sun through an aperture in a shutter, a cell containing a solution of alum or ammonio-sulphate of copper being used to intercept the heat-rays. This mirror is best made of silvered glass, with the silvered side upwards; the pencil next passes through a large condenser, consisting of a photographic landscape lens of 10 to 12 inches focus; the usual achromatic condenser of the microscope is used if needed. The body of the microscope is connected by a cone with the camera, which is most conveniently made entirely open: when in use it is covered with a black cloth, which is supported by the ends and diaphragms. The focussing screen consists of a sheet of albumenised paper pasted over a glass plate: two diagonal cross-lines should be drawn to assist in centreing, and a word in small type pasted in the middle. The focussing is effected by means of a telescope made of the object lens of a large opera-glass and one of the eye-pieces of the microscope, connected by means of a suitable length of tubing. This contrivance enables the operator to observe the image on the screen while in a convenient position for adjusting the microscope and illuminators, and also to watch the process during exposure and alter the light if needed. The eye-pieces are not to be used, as they contract the field and blur the image: magnifying power is better obtained by distance. A sufficiently strong eye-piece should be used in the telescope to give a clear view of the minutiæ of the specimen. The hands are the best heliostat, as the mirror is within easy reach the whole time. Instantaneous micro-photography should be attempted with no power higher than ½ an inch, and the large condenser only should be used. The alum cell should be removed during the time of exposure. A special shutter will also be required between the large condenser and the object to be photographed: this shutter should have no connection with the table, as it would communicate a vibration to the whole of the apparatus at a time when everything should be perfectly still, except the movements of the animalcule to be photographed. A good shutter is made with two boards, having round holes cut in them, and made to slide one over the other, an india-rubber band being the motive power. In this way one hole may be made to pass the other with such speed that the exposure is absolutely instantaneous, and the portraiture of rapidly moving subjects rendered perfectly easy with a good light. Some of the results may be seen in the Indian Museum, London. The higher objectives, such as the 1-16th, work better on the immersion principle, and glycerine or oil of cassia may be used instead of water. When substances with a higher refractive index than water are used, the focal distance between the objective and the glass cover will be increased, and the screw-collar must be adjusted to suit the more refractive medium in which the objective has been immersed. When oil of cassia is employed, the screw-collar should be used so as to close the combination completely, and it will then be found quite possible to focus through rather thick covering glass.

MINING.

There are 11,294 Chinese miners in the Colony of Victoria, many of whom know nothing of the English language; in some of the districts they are employed in quartz mines and alluvial mines of great depth and extent, and it has been found necessary to inform them of the provisions of the Regulation of Mines Statute. The Act to provide for the Regulation and Inspection of Mines has therefore been translated into Chinese.

A controversy having arisen in Australia on the priority of discovery of the nickel deposits of New Caledonia, the Rev. W. B. Clarke, geologist to the Colony of New South Wales, recently gave a history of the discovery before the Royal Society of Sydney. He showed plainly that the nickel was first discovered by M. Jules Garnier in his exploring expedition undertaken under the auspices of the French Colonial Office. Mr. Clarke has had in his collection, since 1864, specimens of nickel ore sent him by M. Garnier, who, on his return to France, made known the abundant existence of nickel in the island. Mr. Clarke transmitted an account of the discovery to the celebrated mineralogist Dana, who described this ore of nickel as a new mineral species, in the most recent edition of his well-known work. Prof. Liversidge, of the University of Sydney, also described the new substance in a learned memoir. Clarke, Dana, and Liversidge gave the name of Garnierite to this new ore, in honour of its discoverer. The great rise in the price of nickel has latterly drawn the attention of manufacturers to these deposits. The serpentines, and generally speaking all the rocks which accompany them, are often covered with a fine green coating—a silicate of alumina, nickel, and magnesia. The price of the metal is now 40 francs per kilo., and the demand is still increasing. Hitherto it has been extracted from speiss, in which it occurs combined with sulphur, arsenic, antimony, cobalt, &c. With the ore of New Caledonia the extraction of the metal will be simpler and the product less impure, the nickel being here combined merely with earthy matters. Though of a characteristic green, this new ore may nevertheless be confounded with carbonate of copper; and perhaps the miner, deceived by this resemblance, may have already met with Garnierite in other countries, and passed it over as a poor ore of copper not worth closer examination. The mines of New Caledonia have already sent to France a ship charged with 500 tons of this mineral.

Some fields of iron ore have been recently discovered in the South of Russia. They are situated partly in the Verchni-Dnieprovsky district of the Ekaterinoslaw Government, and partly in the Elizavetgradsky district of the Cherson Government; iron ore is found here on the rivers Saksagane and Ingouletz, near the village Krivoy-Rog. About 12 miles from this place on the river Saksagane, near the village Tchervonnaia-Balka, large quantities of red hematite are found. Immense layers of hematite, 100 feet thick, are situated near the river Ingouletz and the village Doubovaia-Balka. Mr. Sergius Kern, of St. Petersburg, says that it is estimated that these new fields contain altogether 90,000,000 tons of ore.

The attention of the Madras Government having been again called, after a lapse of nearly forty-two years, to the occurrence of gold in the Malabar District, it was considered advisable that an examination of the country should be made by the Geological Survey of India. It now, however, turns out that the area over which the auriferous deposits and quartz reefs extend is so large that a considerable period of time must elapse before a full report of the whole district can be made. In the meanwhile, as a gold mining company had been started with the intention of opening up the quartz reefs known to exist in Wynád, and more particularly those near Dayvállah, the attention of the Deputy Superintendent, Mr. William King, B.A., was first directed to this region. The country examined up to this time constitutes a local division of this part of the district. The intermediate elevated terrace of mountain-land lying between the low country of Malabar, the loftier *plateau* of the Nilgiri mountains, and the Mysore territory, called the Wynád, has been separated into North Wynád, South Wynád, and South-east Wynád; and these larger areas are again parcelled out, after a native classification, into *Amshams*. In 1793 the gold mines of Malabar appear to have been noticed by the then Governor of Bombay, who tried to get information on the subject; and they were farmed by the Madras Government in 1803. In 1831 Mr. W. Sheffield, Principal Collector of Malabar, wrote an interesting report on these gold mines, upon which Lieut. Woodly Nicholson was deputed to explore the country with a view to the development of this industry. A committee was then appointed, and the Report, dated May 25, 1833, practically condemned the working for gold, as an European industry, in the low country of Malabar. In 1865 or 1866 Mr. Stern paid a prospecting visit to Wynád, and made trial of the alluvial deposits, of which there are several in the form of flat swampy land along the courses of the streams. Within the last year or so attention was again called to the occurrence of gold in the Wynád. Some of the planters had lived in Australia previous to their coffee experiences, and being more or less acquainted with quartz and its occasional associated minerals they were naturally struck with the quartz in Wynád, while they also knew that gold was and is obtained by the natives. The Alpha Gold Company was then started, the prospectus of which states that the stone will yield about 1 ounce of gold to the ton of quartz. The gold obtained from the reefs is of a pale colour; that from the leaders and washings is generally yellow: and that from the surface washings nearly always of a good yellow colour. Up to the present time Mr. King's observations appear to show that quartz-crushing should be a success. The average proportion of gold for fifteen trials on different reefs is at the rate of 7 pennyweights to the ton, and it is almost certain that many of these would have given a better outturn could more perfect crushing apparatus have been used at the time. The fineness or touch of the ore is inferior to that of Australia, but it compares favourably with Californian reef gold. The percentage of 86·86 is given as a fair average, for on looking at the differences between alluvial and matrix gold in other regions, it is found that they agree very closely. The value of Wynád reef gold, when compared with the mint standard of £3 17s. 10½d., is about Rs. 36-12-2 per ounce troy, which is, of course, somewhat lower than the mercantile rate: 7 pennyweights, or the outturn of 1 ton of stone, would then be worth Rs. 12-13-10, which would leave a balance of Rs. 4-2-8 on every ton crushed, even if the high Australian rate were ever attained. Until more is known of the gold-producing powers of the Wynád, no better guidance can be given than the following, by Mr. A. R. C. Selwyn, Director-General Geological Survey of Canada:—"It should not be forgotten that the most favourable indications are not always reliable, and the sanguine prognostications they so frequently give rise to are not borne out by the result of actual working; wherefore I should, even under the most favourable circumstances, not advise any one to invest in such enterprises to an amount beyond what he can afford to lose without serious embarrassment."

GEOLOGY.

GEOLOGY.—In a second paper on "The Bone-caves of Cresswell Crags," the Rev. J. Magens Mello, M.A., F.G.S., gives an account of the examination of a chambered cave called Robin Hood's Cave, situated a little lower down the ravine on the same side, The section of the contents of this cave showed a small thickness of dark surface-soil, containing fragments of Roman and Mediæval pottery, a human incisor, and bones of sheep and other recent animals; over a considerable portion a hard limestone breccia, varying in thickness from a few inches to about 3 feet; beneath this a deposit of light-coloured cave-earth, varying in thickness inversely to the breccia, overlying a dark-red sand about 3 feet thick, with patches of laminated red clay near the base, and containing scattered nodules of black oxide of manganese, and some quartzite and other pebbles, which rested upon a bed of lighter-coloured sands containing blocks of limestone, probably forming part of the original floor of the cavern. The hard stalagmitic breccia contained a great many bones, chiefly of small animals, but with some of reindeer, and teeth of *Rhinoceros tichorhinus*, hyæna, horse, water vole, and numerous flint-flakes and chips, and a few cores. Some of the flakes were of superior workmanship. A few quartzite implements were also found in the breccia. The cave-earth contained a few flint implements, but most of the human relics found in it were of quartzite, and of decidedly palæolithic aspect. There was also an implement of clay-ironstone. The animal remains chiefly found in the cave-earth were teeth of horse, *Rhinoceros tichorhinus*, and hyæna, and fragments of both jaws of the last-mentioned animal. Bones and teeth of reindeer, and teeth of cave-lion and bear also occurred. The red sand underlying the cave-earth contained but few bones, except in one place, where antlers and bones of reindeer and bones of bison and hyæna occurred. At another part a small molar of *Elephas primigenius* was found. A large proportion of the bones had been gnawed by hyænas, to whose agency the author ascribed the presence of most of the animal remains found; but he remarked that no coprolites of hyænas had been met with. Prof. W. Boyd Dawkins has drawn the following conclusions, as to the history of Robin Hood's Cave, from the results of Mr. Mello's researches. He considers that the cave was occupied by hyænas during the formation of the lowest and middle deposits, and that the great majority of the other animals whose remains occur in the cave were dragged into it by hyænas. That they served as food for the latter is shown by the condition of many of the bones. During this period the red sand and clay of the lowest stratum was deposited by occasional floods. The red loam or cave-earth forming the middle stratum was probably introduced during heavy rains. The occupation of the cave by hyænas still continued, but it was disturbed by the visits of Palæolithic hunters. The remains found in the breccia indicate that the cave was inhabited by man, and less frequently visited by hyænas than before. The presence of vertebræ of the hare in the breccia would imply that the hunters who occupied the cave had not the dog as a domestic animal. The traces of man found in the cave consist of fragments of charcoal and implements made of antler and mammoth tooth, quartzite, ironstone, greenstone, and flint. The distribution of these implements in the cave represents three distinct stages. In the cave-earth the existence of man is indicated by the quartzite implements, which are far ruder than those generally formed of the more easily fashioned flint. Out of 94 worked quartzite pebbles only 3 occurred in the breccia, while of 267 worked flints only 8 were met with in the cave-earth. The ruder implements were thus evidently the older, corresponding in general form with those assigned by De Mortillet to "the age of Moustier and St. Acheul," represented in England by the ruder implements of the lower breccia in Kent's Hole. The newer or flint series includes some highly finished implements, such as are referred by De Mortillet to "the age of Solutré," and are found in England in the cave-earth of Kent's Hole and Wookey Hole. The discovery of these implements considerably extends the range of the Palæolithic hunters to the north and west, and at the same time establishes a direct relation in point of time between the ruder types of implements below and the more highly finished ones above.

The mode of occurrence of phosphatic deposits in various localities in Canada has been described to the Geological Society by Principal Dawson, LL.D., F.R.S., &c. Dark phosphatic nodules, containing fragments of *Lingulæ*, abound in the Chazy formation at Allumette Island, Grenville, Hawkesbury, and Lochiel. Similar nodules occur in the Graptolite shales of the Quebec group at Point Levis, and in limestones and conglomerates of the Lower Potsdam at Riviere Ouelle, Kamouraska, and elsewhere on the lower St. Lawrence; these deposits also contain small phosphatic tubes resembling *Serpulites*. The Acadian or Menevian group near St. John, New Brunswick, contains layers of calcareous sandstone blackened with phosphatic matter, consisting of shells and fragments of *Lingulæ*. The author described the general character of the phosphatic nodules examined by him at Kamouraska, and gave the results of analyses made of others from various localities, which furnished from 36·38 to 55·65 per cent of phosphate of lime. A tube from Riviere Ouelle gave 67·53 per cent. The author accepted Dr. Hunt's view of the coprolitic nature of the nodules, and inclined to extend this interpretation to the tubes. The animals producing the coprolites could not be thought to be vegetable feeders; and he remarked that the animals inhabiting the primordial seas employed phosphate of lime in the formation of their hard parts, as had been shown to be the case with *Lingulæ*, *Conularia*, and the Crustaceans. The shells of genus *Hyolithes* also contain a considerable portion of phosphate of lime. Hence the carnivorous animals of the Cambrian seas would probably produce phosphatic coprolites. With regard to the Laurentian apatite deposits, the author stated that they, to a great extent, form beds interstratified with the other members of the series, chiefly in the upper part of the Lower Laurentian above the *Eozoon*-limestones. The mineral often forms compact beds with little foreign matter, sometimes several feet thick, but varying in this respect. Thin layers of apatite sometimes occur in the lines of bedding of the rock. Occasionally disseminated crystals are found throughout thick beds of limestone, and even in beds of magnetite. The veins of apatite are found in irregular fissures; and as they are found principally in the same parts of the seams which contain the beds, the author regarded them as of secondary origin. The Laurentian apatite presents a perfectly crystalline texture, and the containing strata are highly metamorphosed. The author's argument in favour of its organic origin are derived from the supposed organic origin of the iron ores of the Laurentian, from the existence of *Eozoon*, from the want of organic structure in the Silurian deposit described by Mr. D. C. Davies, and the presence of associated graphite in both cases, from the character of the Acadian linguliferous sandstone, which might by metamorphism furnish a pyroxenite rock with masses of apatite, like those of the Laurentian series, and from the prevalence of animals with phosphatic crusts in the Primordial age, and the probability that this occurred also in the earlier Laurentian. The position of the phosphatic deposits above the horizon of *Eozoon* is also adduced by the author as adding probability to the existence of organic agencies at the time of their formation.

At a meeting of the Manchester Geological Society, Mr. Joseph Dickinson, F.G.S., said that recently a member of the Society (Mr. Binney) enquired of him whether, underneath the coal seams of Kilkenny and Queen's County (Leinster coal-field) any trace was found of the *Stigmaria ficoides*—

that was, the rootlets—or whether the means by which the coal had been converted into anthracite had destroyed them. As the question might be interesting to other members, he exhibited some of the fire-clay which underlay these coal seams, showing that the rootlets of the *Stigmaria ficoides* were as plainly to be seen in the floor of some of the seams as in our English seams. Professor Dawkins had observed in the under clay of Pembrokeshire—which was, he supposed, of the same relative antiquity as that of Leinster—rootlets of *stigmaria*; but anything like one of the specimens shown by Mr. Dickinson (a granite-like rock) he had never seen. In that specimen felspar, mica, and quartz were perfectly shown. A specimen of crushed clay, which was exhibited, was very interesting, as showing the enormous pressure to which it had been subjected. Mr. Dickinson explained that the granite-like specimen was taken from underneath the fire-clay that lies below the deep coal seam at Clogh Colliery, Castlecomer.

At the same meeting of this Society, Professor Boyd Dawkins said that, when in New South Wales, he had an opportunity of critically examining the coal-fields of that colony, and there could be no doubt as to its geological age: for, in its lower portion, there were marine fossils, very much after the same fashion as we have in our own coal-field of Lancashire. Above this, in the coal measures proper, there are *lepidodendron*, *calamites*, and *sigillaria*, associated with some peculiar ferns known as *Glossopteris*. Up to the present time the age of that coal-field had been in dispute between the Rev. W. G. Clarke on the one hand, and Prof. McCoy on the other; and it appeared that Prof. McCoy had only argued from the fern alluded to, which occurs in the lower mesozoic strata of India. But, certainly, when we take into consideration the marine fauna—the shells living in the sea of the lower carboniferous strata—and the terrestrial vegetation, which was to a large extent identical with that in our own coal-field, there was not much doubt as the New South Wales coal being Palæozoic.

MINERALOGY.

M. D. Loiseau has discovered a new crystalline organic compound, to which he gives the name of raffinose. Its elementary composition is—Carbon, 36·30; hydrogen, 7·07; oxygen, 56·63; corresponding to the formula $C_6H_7O_7$, or to one of its multiples. It is almost devoid of sweetness; its rotatory power when dissolved in water is greater than that of sugar.

M. Domeyko publishes analyses of two new meteorites from the Desert of Atacama: (1) Meteoric iron from Cachiyuyal. This meteorite weighed 2·55 kilos. On analysis it yielded—Iron, 93·72; nickel, 4·81; cobalt, 0·39; schreibersite, 0·40; earthy matter, 0·50. (2) Meteoric iron from Mejillones. Its composition is—Iron, 95·4; nickel, 3·8; cobalt, 0·1; schreibersite, 0·9. To the same gentleman we are indebted for an analysis of a new mineral named daubreite. This mineral is an earthy mass of a yellowish or greyish white, containing a great number of crystalline lamellæ, opaque, and of a nacreous lustre. Its hardness does not exceed 2 to 2·5, and its specific gravity is 6·4 to 6·5. Its composition is—Sesquioxide of bismuth, 72·60; sesquichloride of bismuth, 22·52; water, 3·84; sesquichloride of iron, 0·72.

There is a rock intervening between the Gneiss Rocks of Mantiqueiro which approximates to epidote, and appears to consist of a single mineral, with the exception of some small granules of infusible quartz. Its specific gravity, according to M. H. Gorceix, is 3·4; it fuses easily, leaving a black slag, the specific gravity of which is only 2·86; its hardness is between 6 and 7. The composition of this rock is—Silica, 38·5; alumina, 25·1; lime, 23·2; protoxide of iron, 10·4; magnesia, traces; loss on ignition, 2·6.

M. A. Damour has examined a calcareous alabaster from Mexico. This material, known in commerce as the onyx of Tecali, varies in colour from milk-white, yellowish white, to pale green, certain samples displaying brown veins shading into red. It takes a fine polish. Its specific gravity is 2·77. It is readily and entirely soluble in nitric acid. Its composition is—Carbonic acid, 43·52; lime, 50·10; magnesia, 1·40; ferrous oxide, 4·10; manganous oxide, 0·22; water, 0·60; silica, traces.

The optical and crystallographical properties and chemical composition of microcline, a new species of triclinic felspar with a potassic base, have been described by M. des Cloizeaux. The composition of this mineral is—Silica, 64·30; alumina, 19·70; ferric oxide, 0·74; potash, 15·60; soda, 0·48; loss on ignition, 0·35. The specific gravity is 2·54.

TECHNOLOGY.

Dr. H. D. Meidinger contributes a valuable paper, on "Progress in the Artificial Production of Cold and Ice," to Dr. A. W. Hofmann's "Report on the Development of the Chemical Arts during the last Ten Years." Speaking of the preservation of ice, he says that ice machines, however they may be eventually improved and their effect increased, will never, in the more northern parts of the temperate zone, where a moderately cold winter with frost is generally experienced, acquire importance enough to meet the demand even approximately. They will serve merely as valuable substitutes to render us independent of the fickleness of the seasons. Even in more southern regions, where ice machines are the only source for obtaining ice, they must work to stock and fill magazines, since the demand does not go hand in hand with the production, but varies with the weather. There is in general no conception of the quantities of ice which certain trades require, and which are consumed in domestic life where its use has grown into a necessity. In 1866 the quantity of ice consumed in New York and its vicinity amounted to 250,000 tons (254,015 metric tons), or 5 cwts per head. The weight stored up was 543,000 tons (551,721 metric tons, whilst the capital employed in the trade amounted to 2,160,000 dollars. The retail price was for quantities of 5 to 12 kilos. 4 pfennige (the German "pfennig" is about the tenth part of an English penny) per kilo., but for quantities of 1 to 10 cwts. only one shilling per cwt. In 1871 a company in Berlin, the "North German Ice Works," stored up 600,000 cwts. of ice, and delivered it to subscribers at 77 pfennige per cwt. The quantities of ice consumed in brewing may be learned from the following data, which the author obtained in 1869 from Dreher's brewery at Klein Schwechat, near Vienna:—This establishment brewed, in 1867, 483,150 Viennese eimers, = 273,463 hectolitres, and stored up 515,600 cwts. (28,874,219 kilos) of ice. In the following year these numbers rose to 492,499 eimers (278,754 hectolitres) of beer and 563,058 cwts. (31,531,924 kilos. of ice. On an average 1 cwt. of ice is used per eimer (56.6 litre). In a prolonged frost of 2 months this quantity can be procured at the cost of 7 Austrian kreutzers (14 pfennige) per cwt. In shorter periods of cold the price rises to from 10 to 12 kreutzers, to which must be added 1 kreutzer for shovelling into the ice cellars. In mild winters the ice is brought in part from Styria; as the cold weather in 1869 set in late, 26,000 cwts. (1,456,031 kilos.) were procured from there, costing, by the time it reached the brewery, 115 florins per 200 cwts.

Schweinfurt-green, known also as mitis-green and mountain-green, is a compound of the arsenite and acetate of copper too frequently used, in spite both of advice and of legal prohibition, for colouring paper-hangings, ball-dresses, artificial flowers, wafers, bon-bons, and toys. Every winter we hear of needlewomen experiencing serious affections after having made up costumes of tarletan coloured or printed with Schweinfurt-green; that dancers wearing similar materials, and with wreaths of artificial flowers in their hair, experience violent headache on the morning after the ball; that similar symptoms have been experienced by persons who have slept for some nights in rooms papered or painted with green; and, lastly, that children have been seized with vomiting after having eaten bon-bons or sucked toys coloured green. M. Kupfferschlæger recommends the following method of detection:—The stained paper, divided into strips, is placed in a porcelain soup-plate, and covered with a solution of chlorate of potash saturated when hot, and the whole is heated in the water-bath till the paper is completely dry. Then it is set on fire, and instantly covered with a large glass bell so that nothing may be lost. The ash is pulverised, and immediately exhausted in the cold with the water which has served to rinse out the bell and the plate after the combustion. Thus all the arsenic combined with the potash is dissolved, and not the oxides of chrome, copper, aluminium, and of tin and lead if present. This colourless solution, filtered, and mixed with sulphuric acid till a slight acid reaction is distinguished, is then introduced into a Marsh's apparatus which has been submitted to a blank test, and found free from arsenic.

It was observed by Kœchlin that woollen cloth dyed blue with indigo was notably decolourised by being allowed to freeze. This result, according to the experiments of Goppelsrœder, was due to ozone present in the air, which acts even at temperatures below 0°, but only when the tissue is wet. Cochineal reds on wool were decidedly impoverished by exposure to the action of ozone for eight days, but were not discharged. Aniline-black was unchanged; aniline-brown on cotton was turned an orange-yellow; magenta, aniline-blues and violets, coralline, and iodine green were discharged, as were also lakes of the dye-woods, and even Turkey-red. Ozone is of great importance in the development of certain colours. Aniline-black, made up with hydrochlorate of aniline, sal-ammoniac, thickening, sulphide of copper, and chlorate of potash, was developed by the aid of ozone in 1 to 1½ hours. For the development of ozone on the large scale Goppelsrœder proposes Gramme's machine, in which the electric spark passes through a conductor repeatedly interrupted. The injurious effects of frost upon alizarin paste, alumina, gelatin, cochineal lakes, mordanted tissues, &c., are well-known, but by no means thoroughly understood.

MM. E. Fremy and PP. Dehérain, in their researches on the sugar beet, show that saline solutions identical in composition act very differently upon beets accordingly as the roots plunge into the solutions themselves, or as the latter merely occupy the pores of the soil. On planting beets of different origin in identical conditions as to soil, manure, and watering, roots are obtained differing in their yield of sugar. An excess of nitrogenous manure lowers the percentage of sugar in all beets, but those of a superior strain preserve still such a quantity of sugar that they may be advantageously treated. To produce from a given surface the maximum of sugar under conditions advantageous alike for grower and manufacturer, we must depend above all on a judicious selection of the seed.